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ABSTRACT

The major problem investigated was to assess the effectiveness of an instructional procedure designed to develop skill in questioning, as a teaching technique, by prospective science teachers. Subproblems investigated were to determine: (1) if skill developed during this instructional sequence would transfer to the student teaching experience; and (2) possible relationships of selected personality factors to the development of questioning skills. The study extended over three quarters. Student teachers were given the Otis Quick-Scoring Mental Ability Test, Gamma Test, Form Em, to measure intelligence; the Myers-Briggs Type Indicator, Form E, to measure personality type; and the Educational Set Scale by Siegel and Siegel, to measure educational set. The 42 individuals involved in the study appeared representative of the population of pre-service secondary school science teachers enrolled at The Ohio State University. Questioning appeared to be a skill that could be developed, through instruction and practice, by these individuals. The development of questioning skill did not appear to be limited by intelligence, sex, personality type, or educational set, insofar as this sample was concerned. (Author)

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THE DEVELOPMENT OF THE SKILL OF QUESTIONING IN  
PROSPECTIVE SECONDARY SCHOOL SCIENCE TEACHERS:  
AN EXTENSION

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#### AUTHOR'S ABSTRACT

The major problem of the study was to extend the research on the development of questioning skill begun as a doctoral dissertation, to determine the combined effects of duration and timing of instruction in questioning techniques.

Twenty-seven preservice teachers were involved in the two-quarter study. The subjects were randomly assigned to three treatment groups: Group R<sub>1</sub> received instruction in questioning distributed over a 14-week period; groups R<sub>2</sub> and R<sub>3</sub> received the same instruction during a seven-week period, in quarter one of the study for group R<sub>3</sub> and in quarter two for R<sub>2</sub>.

Three hypotheses were tested:

1. There is no significant effect of duration (massed vs. distributed practice) of the instructional sequence on skill development in questioning.
2. There is no significant trend over time in development of questioning skill.
3. There are no differential effects in treatments across audiotaping sessions for the criterion variables: Open Questions, Pause Time, Teacher Talk.

Data were gathered by audiotaping lessons during quarter two. Data were analyzed by using programs for correlation, stepwise regression analysis, and analysis of variance.

Hypothesis 1 could not be rejected on the basis of data analysis. Hypothesis 2 could not be rejected for the variables of Open Questions and Teacher Talk. Hypothesis 2 could be rejected for the variable of Pause Time. Hypothesis 3 could not be rejected for the criterion variables of Open Questions and Pause Time. It could be rejected for the criterion variable of Teacher Talk.

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## PREFACE

The assistance of Jane Frowine in preparing typescripts and of Mona Dove in timing questions and verbal interaction is gratefully acknowledged. Special thanks are due Dr. Arthur L. White for his advice and assistance in the statistical analysis portion of this study and to Dr. Robert W. Howe for advice and encouragement.

## INTRODUCTION

Asking questions has long been accepted as a teaching technique. One of the current emphases in science education is the use of "inquiry" techniques. This implies the use of teacher questions structured to enable students to discover information for themselves rather than providing them the information via a lecture. It is assumed that providing students with experiences designed to enable them to learn to think for themselves will not only aid the students in developing a skill (critical thinking) which they can use in any area but will also enable the students to increase their achievement in the particular subject being taught. Ladd (28) investigated the relationship between the inquiry level of teacher questions and student achievement. Using a population of 40 ninth grade earth science classes, Ladd found that group achievement on a post-test was significantly affected by the teacher's inquiry level as determined by teacher questions. The teachers who asked a greater proportion of higher inquiry questions caused a greater change in students as measured by the post-test.

However, not all of the teachers in Ladd's sample asked questions that could be classified as inquiry-type. Other investigators studying teacher behavior in science classrooms [Kleinman (24), Bruce (6)] have also reported that science teachers ask questions that primarily emphasize the recall of factual information. If changes are to be made in the behavior of teachers, programs to effect these changes must be begun during preservice education and must be continued via in-service activities.

The investigator's interest in helping preservice secondary school science teachers develop skill in questioning resulted in a doctoral dissertation completed during the 1969-1970 academic year. The study, its methodology, and findings are available in final report form as Project No. 9-E-126, Grant No. OEG-5-70-0003, The Ohio State University Research Foundation, September, 1970 (4). An abstract of the findings of this study is contained in Appendix A of this report.

### Focus of the Study

The major purpose of the present study was to extend the research on the development of questioning skill to determine the combined effects of the duration and timing of instruction in questioning techniques.

Problems to be investigated were:

- 1) Does continuing the instructional procedure in questioning for a fourteen-week period result in a greater degree of skill development than the same amount of instruction completed during a seven-week period?

- 2) Do the subjects involved in the study reach a peak of skill development as instruction progresses, with only reinforcement resulting after this peak is reached, or does skill development continue throughout the instructional sequence?
- 3) Do students involved in instruction in questioning concurrent with application in the classroom perform better (in terms of questioning behavior) than those whose instruction and application are separated in time?

#### Definition of Terms

The following terms are defined to provide background information.

1. Category system: a method of classifying questions relative to the type of cognitive process the question is designed to stimulate in the student.
2. Closed question: one for which there is a limited range of acceptable responses.
3. Cognitive processes: categories of thinking, identified in hierarchical complexity, as in Bloom's Taxonomy of Educational Objectives: Cognitive Domain or in Guilford's "Structure of Intellect" model, or covert mental operations such as differentiation, identification of common properties, extrapolation.
4. Higher order questions: questions designed to cause students to use and/or formulate ideas rather than just to recall them.
5. Instructional sequence: the structured experiences to which the prospective science teacher will be exposed and the activities in which he will be engaged as he learns to use the category system and then uses it to develop facility in questioning (prior to teaching a lesson and during the lesson). (Also referred to as "instructional procedure.")
6. Microteaching: a teacher education technique which allows an individual to teach a carefully planned lesson, using a clearly defined teaching technique or skill, in a planned series of short encounters (no more than fifteen minutes), with a small group of students (four to eight), either of the age group he plans to teach in the future or of peers.
7. Open question: one for which there is a wide range of acceptable responses.

8. Prospective science teacher: a preservice teacher, enrolled in The College of Education, who is planning to teach science in some secondary school system upon graduation from college.
9. Question: verbal interchange in which the teacher uses interrogative form or solicits information by an imperative statement. Occasions in which the teacher responds to a raised hand or answers "Yes?" are not included in this definition.

#### Rationale for Continuing the Research

The subjects involved in the dissertation research project were pre-service secondary school science teachers enrolled in Education 587.27, Student Teaching in the Secondary Schools: Science, at The Ohio State University. Exposure to instruction in questioning was limited to the first four to five weeks of the student teaching quarter.

This time restriction was imposed because participation in the research was added to the student teaching activities rather than being substituted for some portion of them. The vehicle used to obtain practice in questioning in an instructional setting was microteaching involving peers (preservice elementary school teachers enrolled in Education 511, Elementary Education: Science). Neither the limited duration of the instructional procedure (three microlessons of the teach-reteach variety: six sessions in all) nor the use of peers as students was considered conducive of successful development of the skill of questioning as a teaching technique.

Because the investigator was unable to identify student teaching candidates the quarter prior to enrollment in student teaching, instruction in questioning was begun at the same time the preservice teacher was beginning student teaching.

Three teacher behaviors were used as criterion variables in the dissertation research. These behaviors were (1) asking Open Questions (those to which there is a variety of acceptable responses), (2) pausing for at least three seconds after asking a question in order to allow pupils time to think before responding, and (3) questioning in a manner designed to decrease the percentage of teacher talk during the lesson.

The preservice teachers who received instruction in questioning and who had an opportunity to practice this skill were able to maintain a significantly (.10 level) better level of skill in pausing and decreasing teacher talk than those not receiving instruction. There were no differences in the ability to ask Open Questions during the instructional sequence or during student teaching.

Additional research is needed to provide data for use in determining if increasing the duration of the instructional sequence, if practicing

questioning techniques in instructional situations with public school pupils (as opposed to microteaching using peers as students), and if introducing instruction in questioning prior to working with instructional groups would result in significant gains for the three criterion variables.

Two investigators completed research related to the problems just enumerated. Bereit (3) provided instruction in questioning prior to student teaching. Training consisted of eight weekly, two-hour sessions and was not extended during student teaching. Bereit's sample consisted of eleven senior elementary education students. No information concerning pupil population was given in the document read. These individuals increased their skill in question asking behavior. This skill also increased from end of training to end of student teaching but not at a level of significance (.05). Bereit concluded placement for student teaching appeared to have had a major influence on ability and motivation to make use of prior training. She also emphasized that the time in the preservice program when students get specialized training in analysis of teaching was an important factor to consider in preservice education.

Boeck (5) also provided instruction in questioning techniques prior to student teaching. Her students, college juniors, taught microlessons to small groups of junior high school pupils. Boeck found, in her research, that the individuals who received training increased their rate of high level questioning, decreased the rate of teacher talk, and increased the rate of pupil talk.

#### Review of Related Literature

More than 200 sources were examined and analyzed in reviewing the literature prior to undertaking the dissertation research (4). The search for relevant material has been continued and extended. Studies have been classified as relating to question classification systems, to classrooms other than science, and to science classrooms. Within each of the second and third categories, the materials have been further subdivided into descriptive studies and experimental studies.

The information obtained may be summarized as follows. The question category systems identified were primarily concerned with the cognitive aspects of questions and teachers' questioning behavior [Amidon (2); Clegg, Farley, and Curran (7); Davis *et al.*(13); Gallagher and Aschner (17); Hunter (20,21); Los Angeles City Schools (29); Shrable and Minnis (36)]. A few systems included student response categories but the majority were concerned only with teachers' questions. A commonly-held assumption appeared to be that questions are asked to elicit thinking on the part of the students and the type of question asked is indicative of the level of the response that will result.

When materials concerning classroom questioning practices are considered, the number of studies identified was not sufficiently large

enough to permit a system of grouping into elementary and secondary school levels, preservice teachers vs. in-service teachers, or specific content areas. Some investigators involved both preservice and in-service teachers in their sample. Others used different educational levels and/or involved a variety of subject matter areas.

In science, as in other subjects, teachers dominated the oral activity of the classroom, asking a large number of questions--the bulk of which called for little more than factual-recall thinking operations on the part of their pupils [Adams (1), Bruce (6), Clements (8), Davis and Tinsley (12), Floyd (15), Kleinman (24), Kondo (25), Moyer (31), Pate and Bremer (33), Wilson (37)]. Although there appeared to be much concern for the kinds of questions teachers ask and the relationship of those questions to student learning, little, if anything, was done as a part of these studies to prepare teachers to use questions effectively or to question in a manner designed to involve the majority of the pupils in the class discussion.

The experimental studies, in science and other content areas, provided an indication that programs can be developed for improving questioning behavior [Bereit (3); Boeck (5); Clegg, Farley and Curran (7); Cross (10); Cunningham (11); Houston (19); Johnson (22); Kallenbach (23); Konetski (26); Koran (27); Masla (30); Parsons and Shaftel (32); Rowe (34); Schreiber (35)]. The amount of success achieved appeared to depend in part upon the teachers' perceptions of the situation as well as upon the methodology the instructional programs involved. Again, as in the descriptive studies, the emphasis was upon increasing the variety of questions used. In some of the experimental studies conducted in science classrooms, the investigators were able to report a decrease in the number of low level questions asked [Cunningham (11), Johnson (22), Konetski (26)]. There were no data concerning the number of questions asked in a given period of time although one researcher reported a decrease in the total number of questions asked [Konetski (26)].

The total number of studies identified, in science and in other content areas, was insufficient for generalizing. The majority of research has been done in social studies classrooms. Based on the search of the literature, it does appear reasonable to assume that,

- 1) questions can be classified, with the classification system varying with the investigator's purpose;
- 2) teachers generally tend to ask lower level questions, teaching experience or lack of it and content areas notwithstanding;
- 3) teachers tend to ask frequent questions and fail to provide a sufficient length of time for students to think out an adequate response;

- 4) instructional programs can be designed for use in modifying questioning techniques;
- 5) those instructional programs which have been designed to modify questioning behavior in science have been primarily at the elementary school level;
- 6) there is little or no evidence that attempts have been made to help secondary school teachers increase the length of time they pause after asking a question, to reduce the number of questions they ask per class session, or to involve the majority of students in the verbal interaction of the discussion; and
- 7) the use of such techniques as videotaping the teacher's performance, or microteaching, increases the amount of change an individual makes.

#### Assumptions

Assumptions relating to this study are:

1. The verbal behavior of the teacher is important as a means of transmitting information and of shaping student behavior.
2. The kinds of questions science teachers ask influence the outcomes of science teaching.
3. Teachers must ask higher order questions if they expect their students to emphasize more than factual recall of information in science.
4. Questioning is a skill that can be developed through practice and instruction.

#### Hypotheses

1. There is no significant effect of duration (massed vs. distributed practice) of the instructional sequence on skill development in questioning.
2. There is no significant trend over time in development of questioning skill.
3. There are no differential effects in treatments across audiotaping sessions for the criterion variables: Open Questions, Pause Time, Teacher Talk.

### Limitations of the Study

1. The study was limited to preservice secondary school science teachers enrolled at The Ohio State University during the academic year of 1971-1972 or some portion thereof.
2. The presence of an observer in the classroom will influence the questioning behavior of the particular preservice teacher being observed.
3. The group taught will influence the preservice teacher's questioning behavior.
4. The lesson (content, objectives) will influence the types of questions asked by the preservice teacher.
5. The perceived control of the cooperating teacher will influence the preservice teacher's questioning behavior.

### Delimitations of the Study

1. The study was limited to individuals enrolled in the Junior Program in Science Education at The Ohio State University during the Autumn and Winter Quarters of the academic year of 1971-1972.
2. Data from audiotaped lessons were collected during the Winter Quarter when the college juniors worked with elementary school children.
3. Only the verbal questioning behavior of the preservice teachers was analyzed. The nonverbal components were not considered as a part of this study.
4. The analysis of questioning techniques was limited to randomly selected fifteen-minute segments of the science lesson.
5. The classification of questions was limited by the investigator's competence in interpreting and applying the Question Category System.

## METHODS

This portion of the report contains a brief discussion of the population and sample for the study, design of the study, description of treatments, data-gathering procedures, and procedures used in analyzing the data.

### Population

The population consisted of students enrolled in the junior year of the preservice education program for secondary school science teachers at the Ohio State University. Participation in the study was a part of the teaching techniques component of the program. Students were randomly assigned, at the beginning of the Autumn Quarter, to one of three treatment groups.

Table 1 - Distribution of the Population of the Study

Group	Students
R <sub>1</sub>	10
R <sub>2</sub>	12
R <sub>3</sub>	17

### Design of the Study

A quasi-experimental design in the form of a time-series experiment (Campbell and Stanley, in Gage's Handbook of Research on Teaching, Chapter 5, pp 213-215) was used. A time-series design with the repeated introduction of the experimental variable may be characterized as:

$$X_1 O X_2 O X_3 O X_4 O.$$

The design of the study was:

Quarter One				Quarter Two		
R <sub>1</sub>	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	O	X <sub>4</sub> O	X <sub>5</sub> O
R <sub>2</sub>				X <sub>1</sub> X <sub>2</sub> X <sub>3</sub> O	X <sub>4</sub> O	X <sub>5</sub> O
R <sub>3</sub>	X <sub>1</sub> ----- X <sub>5</sub>			O	O	O

X = instruction in questioning techniques

O = observation

Groups R<sub>1</sub> and R<sub>2</sub> were directly comparable for the amount of instruction, relative to the first observation.

Treatment

For purposes of describing the instruction in questioning, the design may be diagrammed as follows:

1971-1972 Academic Year			
	Autumn Quarter	Winter Quarter	
Weeks	2	9	12
Group R <sub>1</sub>	X-----	Instructional Procedure-----	X
Group R <sub>2</sub>		X--Instructional Pro- --X	cedure
Group R <sub>3</sub>	X--Instructional-X	Procedure	

All three groups received instruction in questioning as a teaching technique, using materials developed as a part of the earlier dissertation research (4). A description of the activities covered in each of the sessions of the instructional procedure is found in Appendix B.

Instruction in questioning techniques was carried out over a two-quarter period for members of group R<sub>1</sub>. Group R<sub>2</sub> received instruction during the second quarter of the junior program, concurrent with teaching science to elementary school children. Group R<sub>3</sub> received instruction in questioning during the first quarter of the junior program, with data on their questioning techniques being gathered in quarter two. (During quarter one all of the students were involved in tutorial activities in junior high school science.)

Members of all of the treatment groups received instruction in questioning in on-campus sessions led by the investigator. Individual conferences concerning the subject's questioning behavior displayed on audiotapes were also conducted by the investigator. Students were supervised during their school experiences by the investigator and two additional faculty members. Comments and criticism concerning questioning were held to a minimum by the other faculty members. Instances in which they felt that students needed to be helped concerning questioning were referred to the investigator.

The instructional procedure consisted of using the material contained in a handbook on questioning and of practicing the strategies of (1) asking Open Questions, (2) pausing, and (3) questioning in a manner designed to decrease the percentage of teacher talk during a lesson. Additional activities, specified in Appendix B, were used to provide experience in classifying questions and in formulating questions when planning lessons.

### Criterion Variables

Three variables were chosen as criterion variables for this study: Open Questions, Pause Time, and Teacher Talk. Each of these variables is further described in Appendix D of this report.

A preservice teacher was considered to have acquired some questioning skill if he could use Open Questions in a lesson. It was assumed that preservice teachers customarily use Closed Questions, Managerial Questions, and Rhetorical Questions but that they do not use Open Questions unless they are made aware of such questions.

Pausing was chosen as the second criterion variable. If teachers ask their pupils questions requiring more than factual-recall thinking operations in the formulation of a response, the pupils need to have time to think before responding. Pausing for at least three seconds was considered a questioning strategy which preservice teachers might not employ unless they were aware of the function which pausing might serve.

Teachers who encourage their pupils to become independent learners in science assume the role of a resource person rather than of an authority who is the final source of all information. It seems logical to assume that teachers serving as resource persons dominate the verbal interaction of the classroom less than do teachers acting as authorities dispensing information. The third criterion variable was that of the percentage of teacher talk heard during the lesson segment analyzed.

### Data-Gathering Procedures

In quarter one, each student taught a fifteen-minute lesson (using a science topic of his or her choice) aimed at the ninth grade level of comprehension. Peers served as students for this microteaching session which was recorded on videotape. These lessons served as baseline data on the questioning behavior of each of the individuals involved in the study.

During quarter two, each of the students recorded three science lessons on audiotape for subsequent self-evaluation and data analysis. Each of these recordings was separated in time by a two to two and one-half week interval. Each of the students was notified prior to the week in which the recording was to be done and was asked to record a lesson in which a discussion was to be a part of the science lesson. The lesson topic and date of recording (within time limitations) was the choice of the individual student.

Several data collection problems were encountered during quarter two, resulting in the elimination of twelve students from the total population. Some individuals had problems with class control and the extreme amount of background noise in some tapes rendered them impossible

to analyze. Several individuals forgot to record a lesson within the given time period. Several others recorded lessons and then inadvertently erased the tapes before the data could be analyzed. As a result, cell sizes decreased, based on the number of usable audiotapes, so that group R<sub>1</sub> contained only 6 individuals; R<sub>2</sub>, 7; and R<sub>3</sub>, 14 at the end of the data-gathering portion of the study.

When teaching assignments were made for quarter two of the study, factors other than treatment group were considered in assigning juniors to elementary school classrooms. As a result, the three treatment groups were not equally represented at any particular grade level. This assignment is shown in Table 2, in terms of taped lessons which could be used for data analysis.

Table 2 - Elementary School Assignments, Quarter Two

Grade	<u>Students with Usable Audiotapes</u>		
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>
Kg.	0	0	3
1	2	2	5
2	0	1	1
3	1	0	1
4	0	0	1
5	2	1	1
6	0	3	2
EMR, Primary	0	0	0
EMR, Intermediate	1	0	0
	<u>6</u>	<u>7</u>	<u>14</u>

Students who entered the junior program during quarter two and did not therefore have a pretest videotape were not included in the analysis. Students who did not have three audiotaped science lessons for data analysis were also dropped from the data on which this report is based.

#### Data-Analysis Procedures

Questions identified in the microteaching lesson and in the lessons taped in the elementary schools were transcribed and made into typescripts.

Although the elementary science lessons varied in length, depending on topic and grade level, only fifteen-minute segments of the verbal interaction were analyzed in order to maintain the standard of comparison with the fifteen-minute microteaching lessons. The segment to be analyzed was randomly selected by applying a random number table to the counter on the tape recorder. Only random numbers ranging from one to twenty five were used to insure that a fifteen-minute sequential segment of the forty-minute tape would be chosen for analysis.

Classification of the questions from the pretest microteaching situation and from the lessons was done by the investigator, using the Question Category System developed for the earlier study (4). A stop-clock was used to time the pause, if any, which followed a question before a response was demanded or received, as well as to time teacher talk and student talk during the portion of the lesson selected for analysis.

Each of the 34 lessons (number included students not considered in data analysis because of missing data) recorded for the third taping was analyzed three times to determine rater reliability.

The reliability of the average of the three ratings, each separated in time by two-week intervals, was determined as specified by Guilford (18:300), using a modified form of a formula for intraclass correlation. Data used to make the calculations were obtained by processing the coded question classifications in a BMD 02V program, analysis of variance for factorial design, using an IBM 360 computer.

The formula specified for intraclass correlation is:

$$r_{kk} = \frac{V_r - V_e}{V_r}$$

where

$V_r$  = variance between rows (in this study, a specific question)  
 $V_e$  = variance for residuals (or error)

The results of the calculations are shown in Table 3, below.

Table 3 - Reliability of Investigator

Category Level	Investigator
I	.93
II	.92
III	.90

### Techniques Used to Test the Hypotheses

Complete information (a videotape of the microteaching lesson used as a pretest measure and audiotapes of three elementary science lessons) was available for 27 juniors. Data obtained from the analyses of these four sessions were coded for computer programming to test the three hypotheses involved in the study. The equivalence of the three treatment groups at the beginning of the study was also investigated, using pretest data.

Hypothesis 1. There is no significant effect of duration (massed vs. distributed practice) of the instructional sequence on skill development in questioning.

Data obtained from tapes were submitted to programs for correlation, for stepwise regression analysis, and for analysis of variance.

Hypothesis 2. There is no significant trend over time in development of questioning skill.

Data from the tapes were analyzed, using polynomial regression and analysis of variance techniques.

Hypothesis 3. There are no differential effects in treatments across audiotaping sessions for the criterion variables: Open Questions, Pause Time, Teacher Talk.

Data obtained from the tapes were analyzed, using analysis of variance techniques.

## RESULTS

### Pre-Test Analysis

The pre-test situation consisted of a fifteen-minute microteaching lesson in which peers served as ninth grade students. The lessons were recorded on videotape. Data from these videotaped microteaching lessons were analyzed to determine if the three treatment groups were equivalent. The students had been randomly assigned to each of the three groups.

Twelve variables were used in this analysis. These variables are listed in Table 4.

Table 4 - Variables Involved in the Study

Variable	Source
Closed Question Ratio	Closed Questions/Total Questions
Open Question Ratio	Open Questions/Total Questions
Managerial Question Ratio	Managerial Questions/Total Questions
Rhetorical Question Ratio	Rhetorical Questions/Total Questions
Closed Questions:Ti	Closed Questions/Lesson Length*
Open Questions:Ti	Open Questions/Lesson Length*
Managerial Questions:Ti	Managerial Questions/Lesson Length*
Rhetorical Questions:Ti	Rhetorical Questions/Lesson Length*
Pause Time Mean	Mean Pause*
Teacher Talk	Amount of Teacher Talk/Lesson Length*
Student Talk	Amount of Student Talk/Lesson Length*
Silence**	"Silence"/Lesson Length*

\*All variables involving time were computed in seconds

\*\*The variable of Silence was considered to consist of any portions of the lesson segment in which teacher and students were not interacting. It consisted of more than silence in that it included pause time, confusion, interruptions (visitor entering the classroom, announcement over the public address system, remarks by the cooperating teacher, etc.), and intervals in which students worked on an activity without teacher guidance or intervention.

The means and standard deviations for these variables for the total population and for each of the treatment groups are presented in Table 5.

Table 5 - Means and Standard Deviations for the Twelve Variables for the Three Treatment Groups on the Pre-Test Tape

Variable	Total Sample (N=27)		R <sub>1</sub> (N=6)		R <sub>2</sub> (N=7)		R <sub>3</sub> (N=14)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Closed Questions	0.60	0.18	0.65	0.25	0.70	0.14	0.53	0.14
Open Questions	0.14	0.10	0.14	0.16	0.12	0.05	0.15	0.10
Managerial Questions	0.20	0.13	0.15	0.13	0.14	0.13	0.26	0.11
Rhetorical Questions	0.06	0.06	0.06	0.08	0.04	0.05	0.07	0.07
Closed Questions:Ti	0.02	0.02	0.01	0.01	0.04	0.01	0.02	0.01
Open Questions:Ti	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Managerial Questions:Ti	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Rhetorical Questions:Ti	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0
Pause Time Mean	1.32	0.58	1.49	0.69	1.11	0.31	1.37	0.64
Teacher Talk	0.58	0.21	0.76	0.33	0.54	0.13	0.52	0.13
Student Talk	0.09	0.06	0.06	0.05	0.14	0.07	0.08	0.04
Silence	0.33	0.21	0.18	0.31	0.32	0.15	0.40	0.15

Multiple analyses of variance and stepwise regression analysis programs were used to determine if groups were equivalent. The three groups were found not to be equivalent for four variables: Managerial Questions, Closed Questions:Ti, Teacher Talk, Student Talk. Table 6 contains the results of the multivariate analysis of the variance program. Table 7 contains a summary of the regression analyses for the pre-test data.

Table 6 - Analysis of Variance for the Twelve Variables of the Study Pre-Test Tape

Variable	F (2, 21)	Mean SQ	P Less Than*
1	2.240	0.062	0.131
2	0.174	0.002	0.842
3	2.071	0.033	0.151
4	0.307	0.001	0.739
5	8.025	0.001	0.003
6	0.100	0.000	0.906
7	1.432	0.000	0.261
8	0.569	0.000	0.575
9	1.397	0.432	0.269
10	3.224	0.127	0.060
11	4.030	0.012	0.033
12	2.397	0.097	0.115

\* $\alpha$  level

Table 7 - Summary of Regression Analyses Using Questioning Technique Variables as Independent Predictor Variables of Treatment Group Membership

Independent Variable	Multiple R	Multiple R <sup>2</sup>	Increase in Multiple R <sup>2</sup>	df	F
<u>Treatment Group R<sub>1</sub></u>					
Teacher Talk	0.4758	0.2264	0.2264	1,25	7.3173
Managerial Questions/Total	0.6493	0.4215	0.1170	3,23	4.6505
<u>Treatment Group R<sub>2</sub></u>					
Closed Questions/ Time	0.5157	0.2659	0.2659	1,25	9.0566
Student Talk	0.5950	0.3451	0.0881	2,24	3.2742
<u>Treatment Group R<sub>3</sub></u>					
Managerial Questions/Total	0.4474	0.2002	0.2002	1,25	6.2572

Critical F at .05 level of significance = 4.24 for 1,25 df  
 3.40 for 2,24 df  
 3.03 for 3,23 df

The variables of Managerial Questions, Closed Questions:Ti, Teacher Talk, and Student Talk were used as covariates for subsequent data analyses.

### Reporting of Results

Each of the three hypotheses of the study was stated in the null form. The alpha level chosen was that of .05 significance level. Two-tailed or nondirectional tests were used.

In this report, the results will be presented in two parts: those concerned with the analyses of variance and those concerned with polynomial regression.

The hypotheses to be tested were:

Hypothesis 1. There is no significant effect of duration (massed vs. distributed practice) of the instructional sequence on skill development in questioning.

Hypothesis 2. There is no significant trend over time in development of questioning skill.

Hypothesis 3. There are no differential effects in treatments across audiotaping sessions for the criterion variables: Open Questions, Pause Time, Teacher Talk.

Multivariate analysis of variance techniques were used to test all three hypotheses of this study. Additional information for testing hypothesis two was obtained from the polynomial regression program.

### Analysis of Variance Results

Data from the tapes were analyzed by multivariate analysis of variance, to test hypotheses one, two and three.

When the data were analyzed for each of the criterion variables (Open Questions, Pause Time, Teacher Talk), using analysis of variance techniques, no significant effect was found for the variable of Open Questions. A summary of this analysis is presented in Table 8.

Table 8 - Analysis of Covariance<sup>a</sup> of Treatments by Audio-taping for Open Questions/Total Questions

Source of Variation	SS	df	MS	F
<u>Between subjects</u>		<u>23</u>		
R	0.001	2	0.0005	0.315
PWR	0.064	21	0.0038	
Adjusted for covariance		(17)		
<u>Within subjects</u>		<u>48</u>		
A	0.015	2	0.0075	1.0416
RA	0.009	4	0.0023	0.3125
APWR	0.272	42	0.0072	
Adjusted for covariance		(38)		

A = Audiotape

R = Treatment Group

RA = Interaction of Audiotape and Treatment Group

PWR = Persons nested within Treatment Group

APWR = Interaction of Audiotape with Persons Nested within Treatment Group

<sup>a</sup>Covariates were pre-test measures for Managerial Questions, Closed Questions: Ti, Teacher Talk, Student Talk

The variable of Pause Time mean was not significant at the .05 level. There was, however, a significant interaction effect of audiotape with treatment group at the .10 level for this variable (Table 9).

Table 9 - Analysis of Covariance of Treatments by Audio-taping for Pause Time Mean (sec)

Source of Variation	SS	df	MS	F
<u>Between subjects</u>		<u>23</u>		
R	0.180	2	0.9000	1.9819
PWR	7.720	21	0.4541	
Adjusted for covariance		(17)		
<u>Within subjects</u>		<u>48</u>		
A	1.129	2	0.5645	1.7236
RA	3.078	4	0.7695	2.3496*
APWR	12.447	42	0.3276	
Adjusted for covariance		(38)		

\*Significant at .10 level (df 4,38)

Critical value at .10 level = 2.11

When the variable of Pause Time Mean was considered for the three treatment groups by audiotaping session, the following information was identified, as is shown in Table 10 and Figure 1, below.

Table 10 - Pause Time Means for Treatment Groups  
By Audiotape Session

	AT-1	AT-2	AT-3
R <sub>1</sub>	0.963	1.526	1.188
R <sub>2</sub>	1.646	1.312	0.975
R <sub>3</sub>	1.224	1.346	0.922

The trend of the variable of Pause Time Mean is shown, over time, in Figure 1.

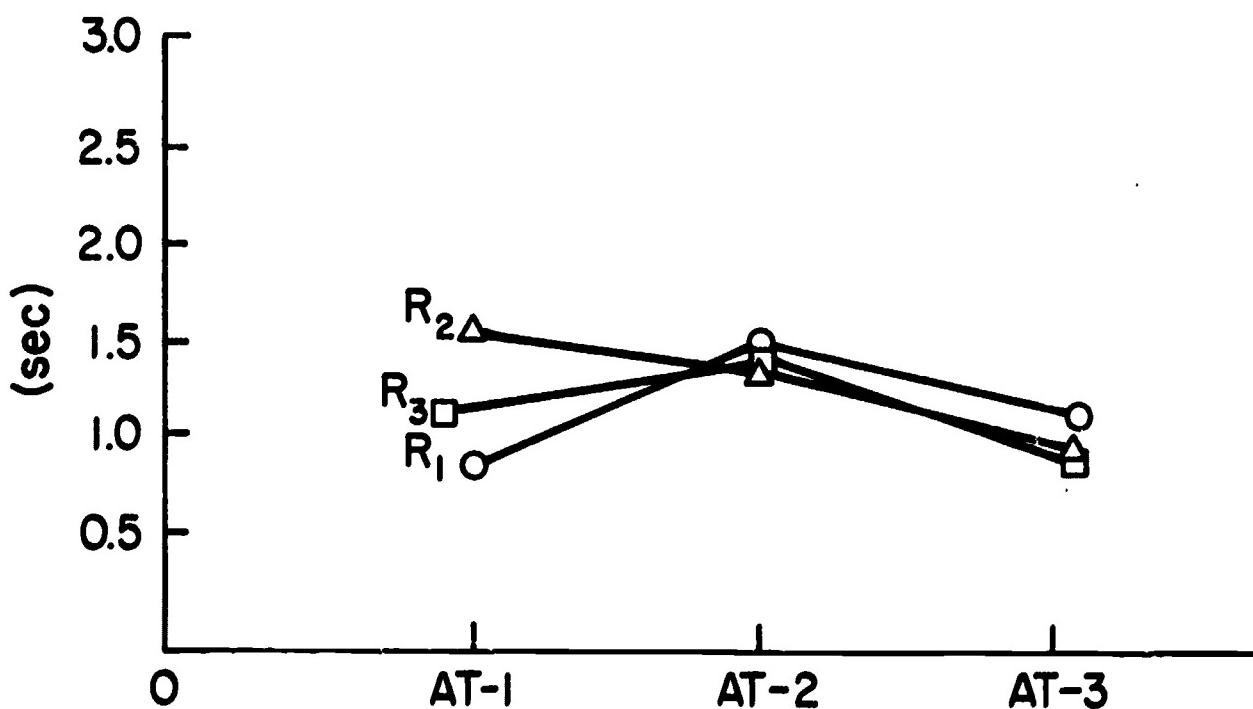


Figure 1 - Pause Time Means (adjusted for covariance) Across Audiotapes by Treatment Groups

To determine if the difference in means between the Pause Times of groups R<sub>1</sub> and R<sub>2</sub>, shown in Figure 1, was significant, a t-test of the significance of the difference between two means for independent samples was made. The following formula\*

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left( \frac{N_1 S_1^2 + N_2 S_2^2}{N_1 + N_2 - 2} \right) \left( \frac{N_1 + N_2}{N_1 N_2} \right)}}$$

$$t = \frac{0.963 - 1.646}{\sqrt{\left( \frac{6 \cdot .42 + 7 \cdot .47}{6 + 7 - 2} \right) \left( \frac{6 + 7}{6 \cdot 7} \right)}}$$

$$t = \frac{.683}{.4}$$

$$t = 1.707$$

To correct for using multiple t-tests, the .05 level of significance was adopted, so the expected error rate would be .10.

The critical value of t at the .05 level of significance, with 11 df, is 2.201. Therefore, the difference between the means for groups R<sub>1</sub> and R<sub>2</sub> on audiotape I for Pause Time was not significant.

When the Pause Time mean variable was considered for the audio-taping sessions by treatment group, the following picture resulted (Table 11 and Figure 2).

Table 11 - Pause Time Means for Audiotape Session by Treatment Group

	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>
AT-1	0.963	1.646	1.224
AT-2	1.526	1.312	1.346
AT-3	1.188	0.975	0.922

\*Downie and Heath, Basic Statistical Methods, Harper and Row, 1970, p. 185.

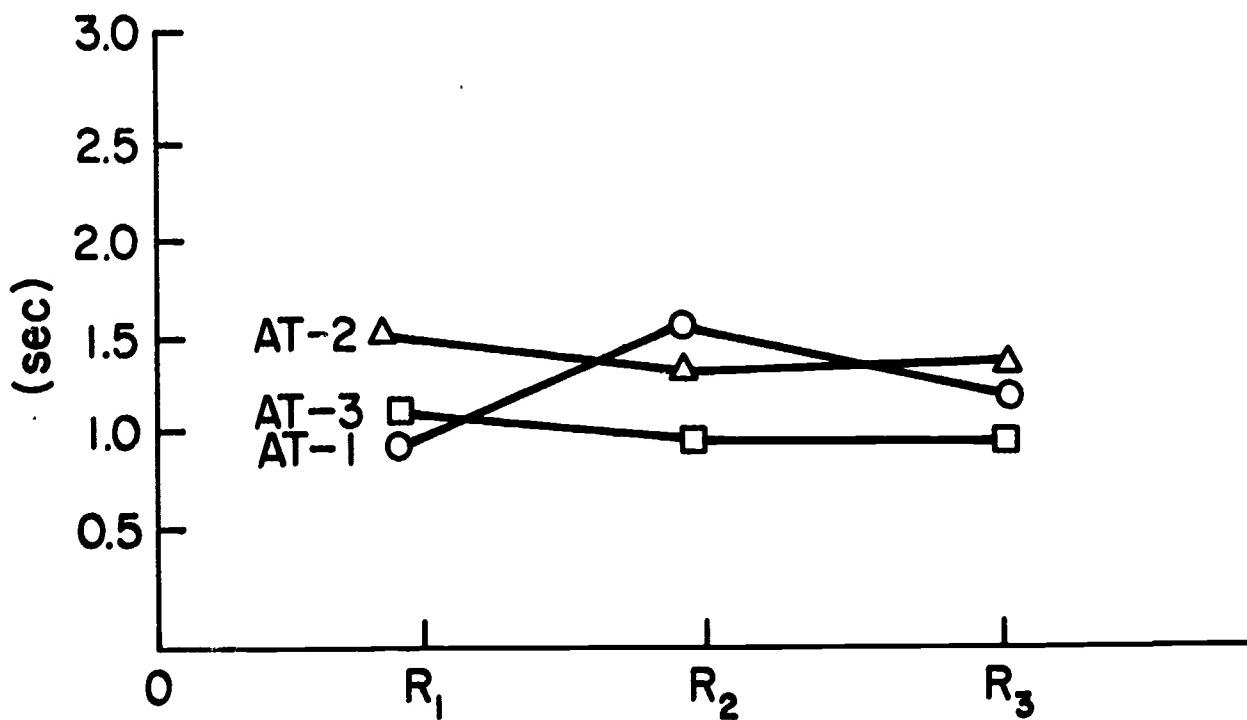


Figure 2 - Pause Time Means (adjusted for covariance) Across Treatment Groups by Audiotape

The variable of Teacher Talk was significant at the .05 level. There was a significant interaction effect of audiotape with treatment group, shown in Table 12.

Table 12 - Analysis of Covariance of Treatments by Audio-taping for Percentage of Teacher Talk

Source of Variation	SS	df	MS	F
<u>Between subjects</u>		23		
R	0.018	2	0.0090	0.0302
PWR	0.506	21	0.2976	
Adjusted for covariance		(17)		
<u>Within subjects</u>		48		
A	0.011	2	0.0055	0.6790
RA	0.118	4	0.0295	3.6420*
APWR	0.309	42	0.0081	
Adjusted for covariance		(38)		

\*Significant at .05 level (df 4,38)  
Critical value at .05 level = 2.62

This variable was also inspected for the three treatment groups by audiotaping session, as shown in Table 13 and Figure 3.

Table 13 - Means for Teacher Talk for Treatment Groups by Audiotape Session

	AT-1	AT-2	AT-3
R <sub>1</sub>	0.433	0.348	0.398
R <sub>2</sub>	0.331	0.362	0.315
R <sub>3</sub>	0.308	0.375	0.355

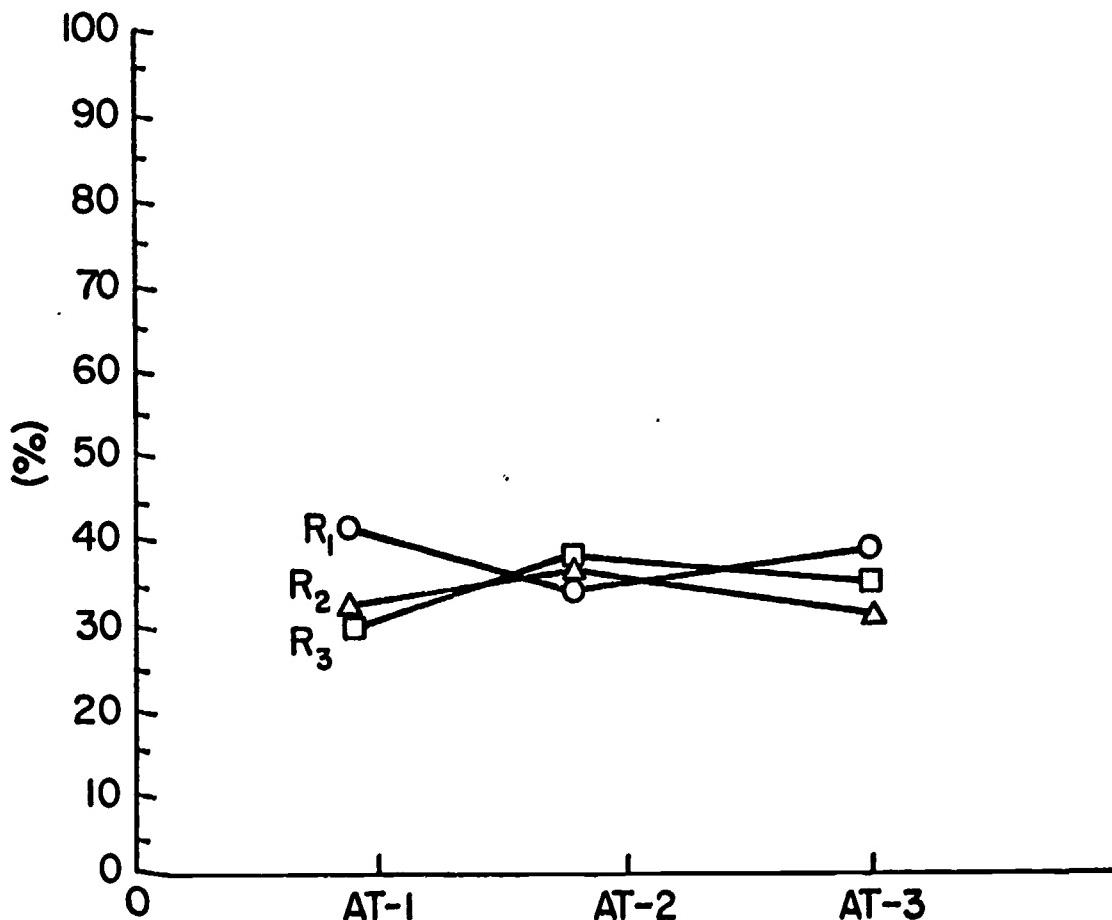


Figure 3 - Teacher Talk (adjusted for covariance) Across Audiotapes by Treatment Groups

When the variable of Teacher Talk was considered from the perspective of the three audiotapes by treatment group, the information presented in Table 14 and Figure 4 was identified.

Table 14 - Means for Teacher Talk for Audiotape Session by Treatment Group

	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>
AT-1	0.433	0.331	0.308
AT-2	0.348	0.362	0.375
AT-3	0.398	0.315	0.355

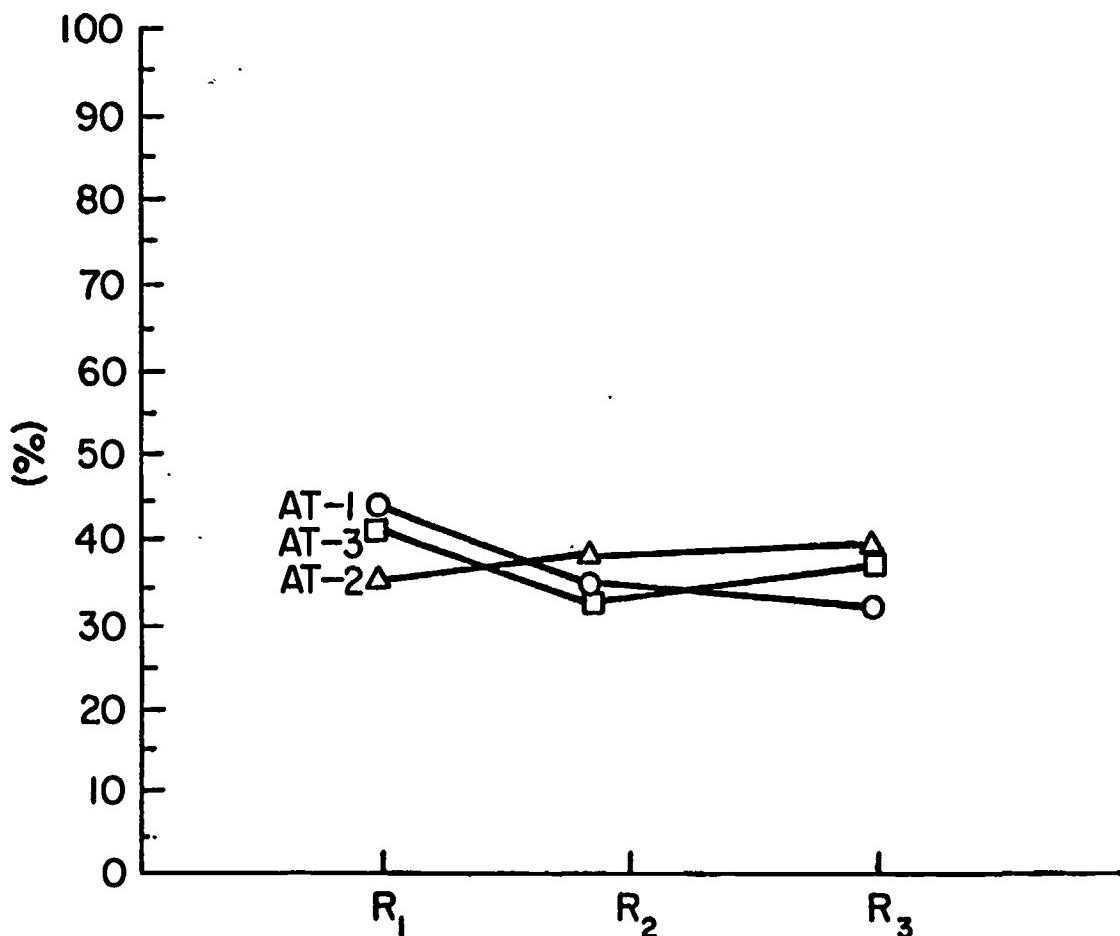


Figure 4 - Teacher Talk (adjusted for covariance) Across Treatment Groups by Audiotapes

An additional variable, Rhetorical Questions, although not one of the criterion variables, exhibited a significant effect. The significant effect was in the audiotaping, shown in Table 15.

Table 15 - Analysis of Variance for Rhetorical Questions/  
Total Questions Audiotapes I, II and III

Source of Variation	SS	df	MS	F
<u>Between subjects</u>		23		
R	0.005	2	0.0025	0.4310
PWR	0.100	21	0.0058	
Adjusted for covariance		(17)		
<u>Within subjects</u>		48		
A	0.039	2	0.0195	6.0937*
RA	0.016	4	0.0040	1.2500
APWR	0.121	42	0.0032	
Adjusted for covariance		(38)		

\*Significant at .01 level (df 2,38)

Critical value at .01 level = 5.21

To determine where the significant difference occurred, the Tukey method for testing differences between means was used (38:77, 87). The means for audiotapes I, II, and III were 0.094, 0.065, 0.053, respectively.

Table 16 - Audiotape Adjusted Means Differences for  
Rhetorical Questions/Total Questions

	AT-3	AT-2	AT-1
AT-3	0	.012	.041
AT-2		0	.029
AT-1			0

Using the following formula, the critical difference between means was calculated.

$$\bar{X}_i - \bar{X}_j = q \sqrt{\frac{MS_e}{n}}$$

$q = 2.86$  (studentized range statistic,  $df = 2,38$ )

$MS_e$  = variance estimate (within groups)

$n$  = group size

The critical difference between means was then calculated.

$$\begin{aligned}\text{Critical difference} &= 2.86 \sqrt{\frac{.0032}{24}} \\ &= 2.86 \sqrt{1.33} \\ &= .032\end{aligned}$$

The difference of AT-3 and AT-1, .041, exceeded the critical difference, indicating that there was a significant decrease of the use of Rhetorical Questions from the first audiotape to the third.

#### Polynomial Regression Results: Four Tapes

Each of the twelve variables was analyzed by polynomial regression (EMD05R0 for each of the three treatment groups, using data from the pre-test lesson and from the three lessons audiotaped in the elementary schools.) The analyses were tests for significance of linear, quadratic, and cubic relationships of the dependent variables across audiotapings. The statistical test used was the F-ratio from analysis of variance.

One criterion variable and several other variables were found to have F-ratios at or above the .05 level of significance. The criterion variable exhibiting an F-ratio at the .05 level of significance was Teacher Talk.

The F-ratio indicating a linear regression was the largest for each of the three treatment groups when Teacher Talk was analyzed. The F-ratios are shown in Table 17.

Table 17 - F-Ratios Resulting from Analysis of Variance  
for Polynomial Regression, Goodness of Fit  
Test, for Teacher Talk Variable

Polynomial	Treatment Group					
	R <sub>1</sub>		R <sub>2</sub>		R <sub>3</sub>	
	F	df	F	df	F	df
1st degree (linear)	8.84	(1,22)	6.90	(1,26)	10.47	(1,54)
2nd degree (quadratic)	8.10	(2,21)	4.60	(2,25)	9.48	(2,53)
3rd degree (cubic)	5.21	(3,20)	3.88	(3,24)	7.51	(3,52)

Critical values at .05 level for R<sub>1</sub> = 4.30

R<sub>2</sub> = 4.22

R<sub>3</sub> = 4.02

Table 18 contains a summary of the means for each of the taping sessions for each treatment group for the variable of Teacher Talk.

Table 18 - Means for Per Cent of Teacher Talk for the Four Taping Sessions by Treatment Group

Treatment Group	Taping Session			
	Pre-Test	AT-1	AT-2	AT-3
R <sub>1</sub>	76	42	34	39
R <sub>2</sub>	54	36	39	34
R <sub>3</sub>	52	33	35	34

Figure 5 contains a plot of the Teacher Talk variable over the four taping sessions (pre-test and three audiotapes) by treatment group.

Although there were no F-ratios at the .05 level of significance for the variables of Open Questions and Pause Time, plots of these two criterion variables are also included to provide reference points when the results presented in this section are interpreted in the next section of the report.

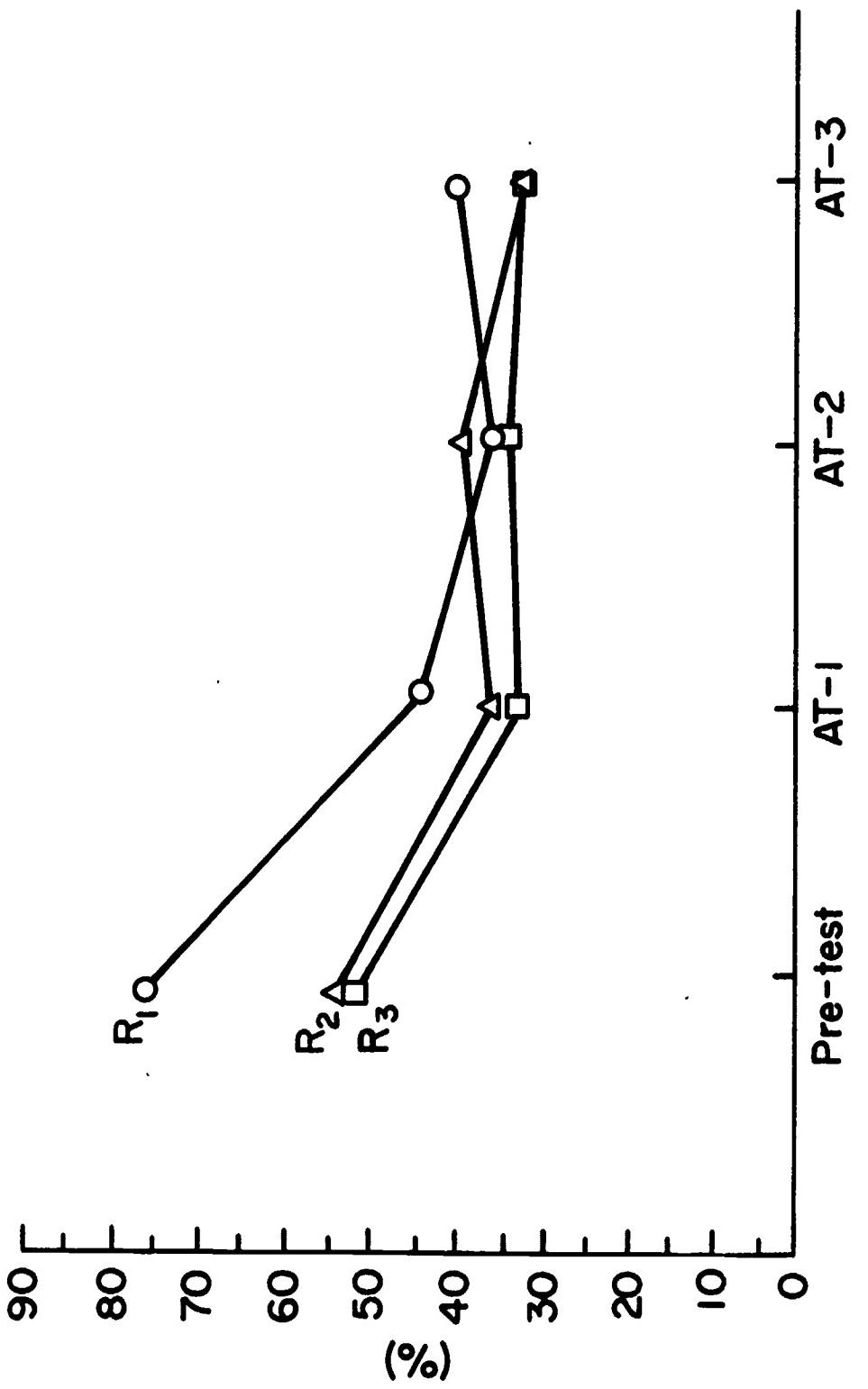


Figure 5 - Plot of Teacher Talk Variable over the Four Taping Sessions by Treatment Group

Table 19 contains a summary of the means for the percentage of Open Questions for the four taping sessions by treatment group. Figure 6 is the plot illustrating the trend of this variable over time.

Table 19 - Means for Per Cent Open Questions for the Four Taping Sessions by Treatment Group

Treatment Group	Pre-Test	Taping Session		
		AT-1	AT-2	AT-3
R <sub>1</sub>	14	09	05	07
R <sub>2</sub>	12	10	10	10
R <sub>3</sub>	15	12	07	10

Pause Time, the third criterion variable, also did not exhibit any F-ratios at the .05 level of significance for any of the treatment groups. Nevertheless, information concerning its trend over time is included here, in Table 20 and Figure 7, as reference material for the interpretation of the data.

Table 20 - Means for Pause Time Mean for the Four Taping Sessions by Treatment Group

Treatment Group	Pre-Test	Taping Session		
		AT-1	AT-2	AT-3
R <sub>1</sub>	1.49	1.04	1.60	1.26
R <sub>2</sub>	1.11	1.56	1.22	0.89
R <sub>3</sub>	1.37	1.12	1.29	1.02

Information concerning two other variables, Managerial Questions and Student Talk, is included here because both of these variables exhibited F-ratios at or above the .05 level of significance in the analysis of variance for the polynomial regression program.

Table 21 contains a summary of the F-ratios for the Percentage of Managerial Questions Variable.

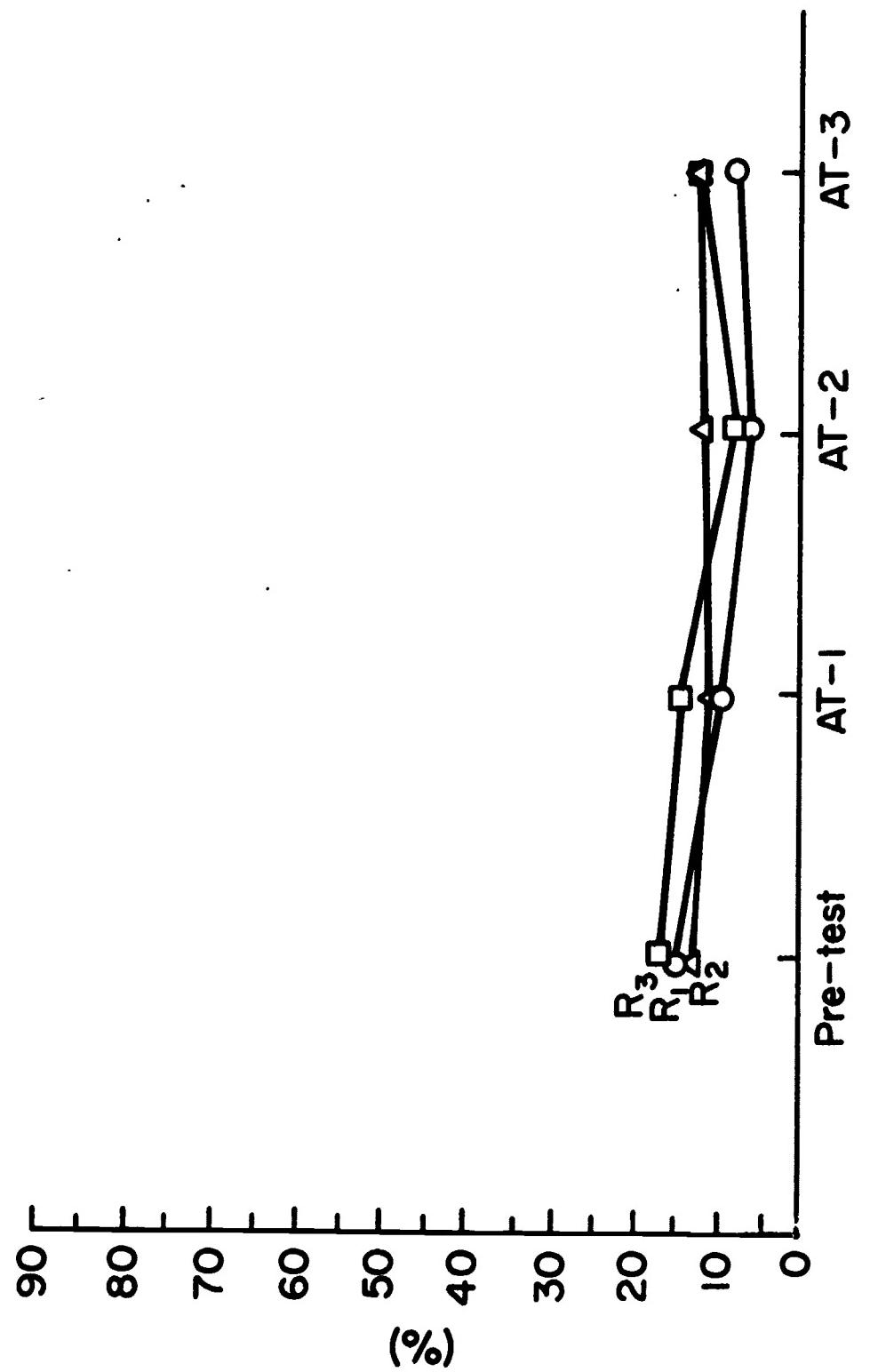


Figure 6 - Plot of Open Question Percentages over the Four Taping Sessions by Treatment Group

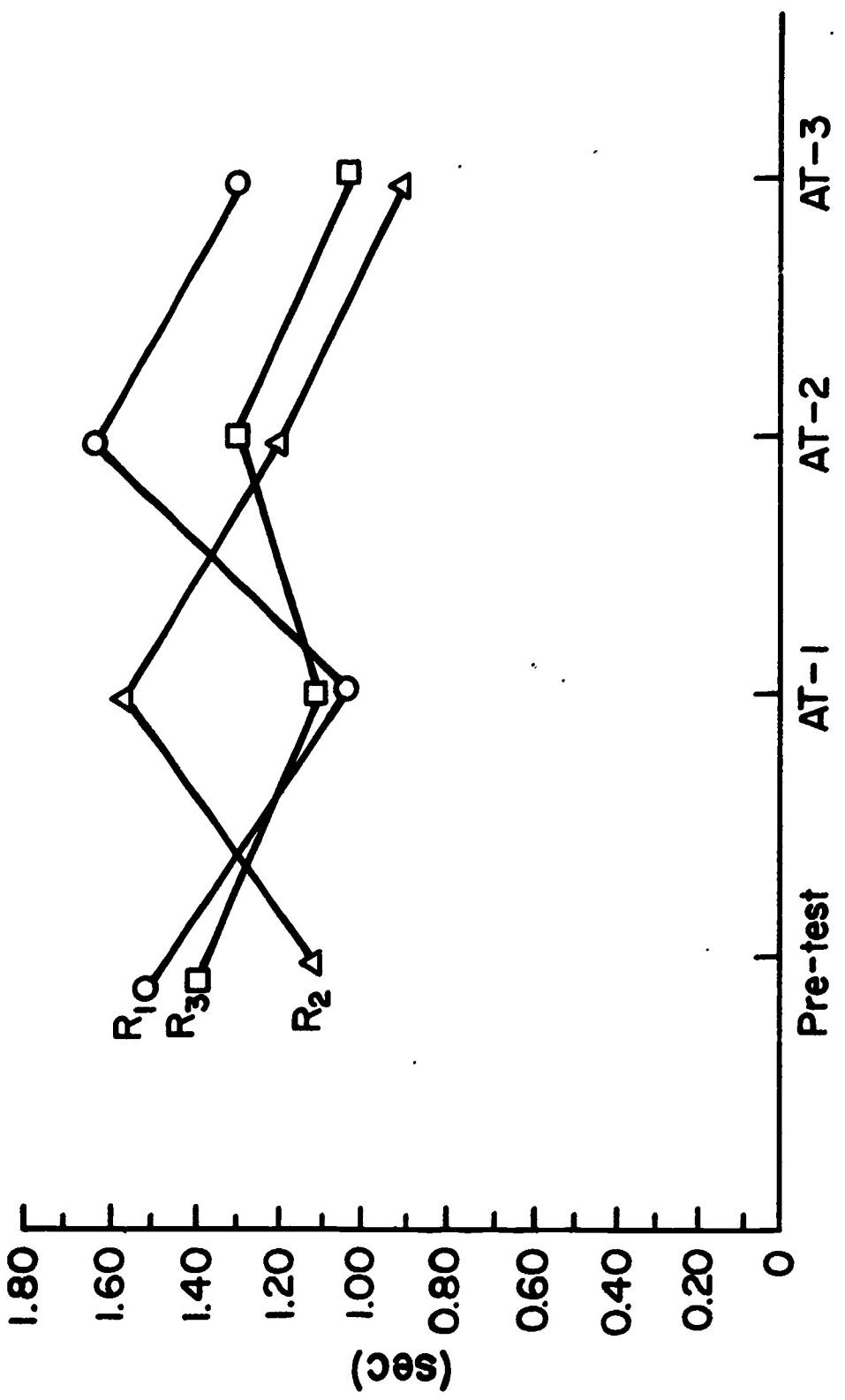


Figure 7 - Plot of Pause Time Mean over the Four Taping Sessions by Treatment Group

Table 21 - F-Ratios Resulting from Analysis of Variance for Polynomial Regression, Goodness of Fit Test, for Per Cent Managerial Questions Variable

Polynomial	Treatment Group					
	R <sub>1</sub>		R <sub>2</sub>		R <sub>3</sub>	
	F	df	F	df	F	df
1st degree (linear)	5.23	(1,22)	1.28	(1,26)	2.92	(1,54)
2nd degree (quadratic)	2.52	(2,21)	1.24	(2,25)	2.97	(2,53)
3rd degree (cubic)	2.16	(3,20)	0.97	(3,24)	1.98	(3,52)

Critical value for  
.05 level of significance      R<sub>1</sub> = 4.30  
                                        R<sub>2</sub> = 4.22  
                                        R<sub>3</sub> = 4.02

Only one treatment group, R<sub>1</sub>, exhibited a significant F-ratio for linear regression for this variable ( $\alpha = 4.30$ , df = 1,22).

Table 22 contains the means for percentage of the Managerial Questions variable for the four taping sessions by treatment group.

Table 22 - Means for Per Cent Managerial Questions for the Four Taping Sessions by Treatment Group

Treatment Group	Pre-Test	Taping Session		
		AT-1	AT-2	AT-3
R <sub>1</sub>	15	24	21	32
R <sub>2</sub>	16	24	22	22
R <sub>3</sub>	26	22	26	32

Figure 8 shows the plot of this variable over time.

The F-ratios resulting from the analysis of variance for polynomial regression, goodness of fit test, for the variable of Student Talk are presented in Table 23.

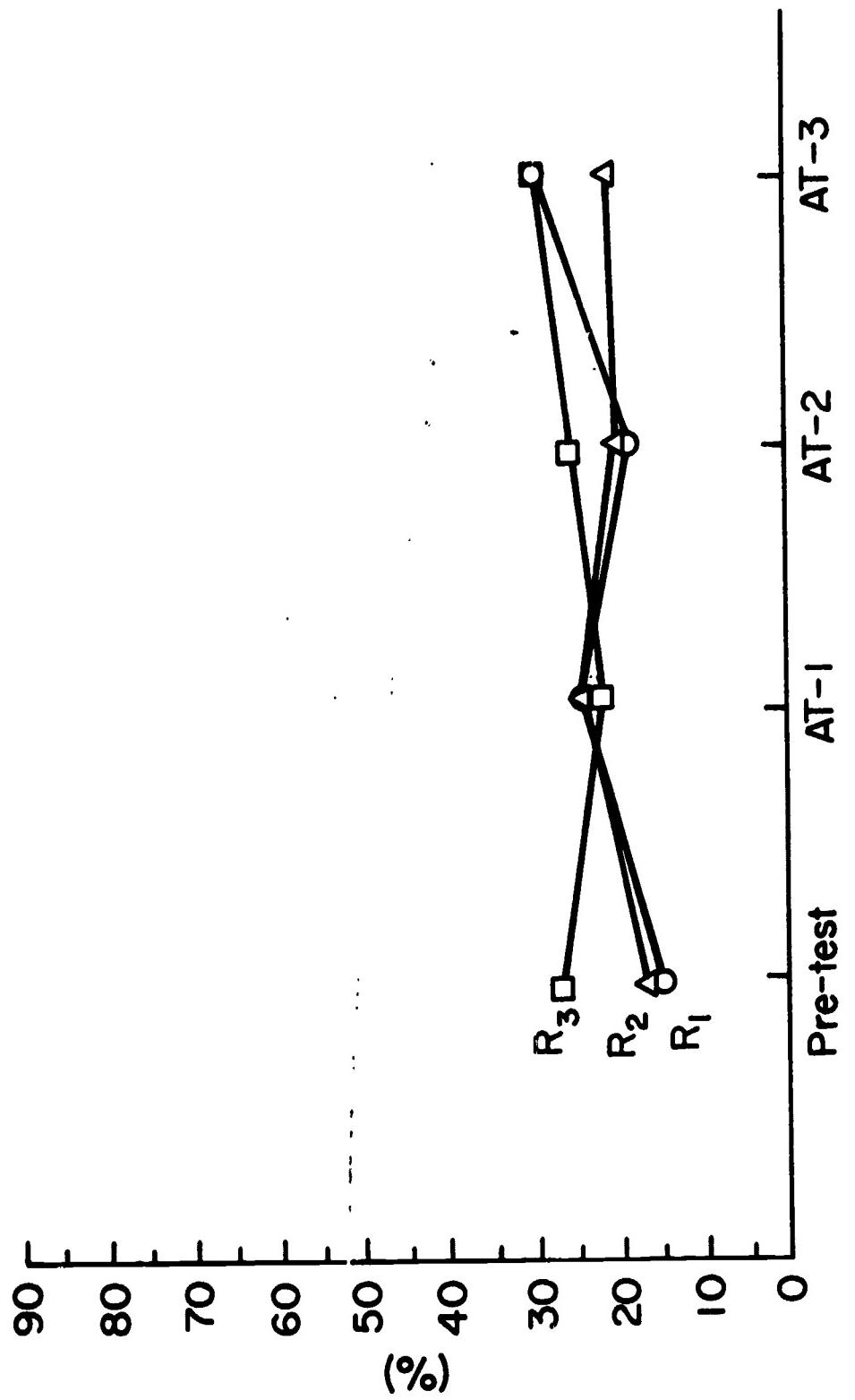


Figure 8 - Plot of Managerial Question Percentages over the Four Taping Sessions by Treatment Group

Table 23 - F-Ratios Resulting from Analysis of Variance  
for Polynomial Regression, Goodness of Fit  
Test, for Student Talk Variable

Polynomial	Treatment Group					
	R <sub>1</sub>		R <sub>2</sub>		R <sub>3</sub>	
1st degree (linear)	F 15.00	df (1,22)	F 3.42	df (1,26)	F 29.23	df (1,54)
2nd degree (quadratic)	7.51	(2,21)	2.06	(2,25)	23.02	(2,53)
3rd degree (cubic)	6.07	(3,20)	1.67	(3,24)	16.50	(3,52)

Critical values at .01 level of significance      R<sub>1</sub> = 7.94  
     R<sub>2</sub> = 7.22  
     R<sub>3</sub> = 7.11

Both treatment groups R<sub>1</sub> and R<sub>3</sub>, exhibited F-ratios that were significant at the .01 level. The largest F-ratio for treatment group R<sub>2</sub> did not approach even the .05 level of significance ( $\alpha = 4.22$ , df = 1,26).

Table 24 contains a summary of the means of the variable of Student Talk for the four taping sessions by treatment group.

Table 24 - Means for Student Talk for the Four Taping Sessions by Treatment Group

Treatment Group	Taping Session		
	Pre-Test	AT-1	AT-2
R <sub>1</sub>	06	20	19
R <sub>2</sub>	14	25	23
R <sub>3</sub>	08	25	27

Figure 9 shows the plot for the variable of Student Talk over time for each treatment group.

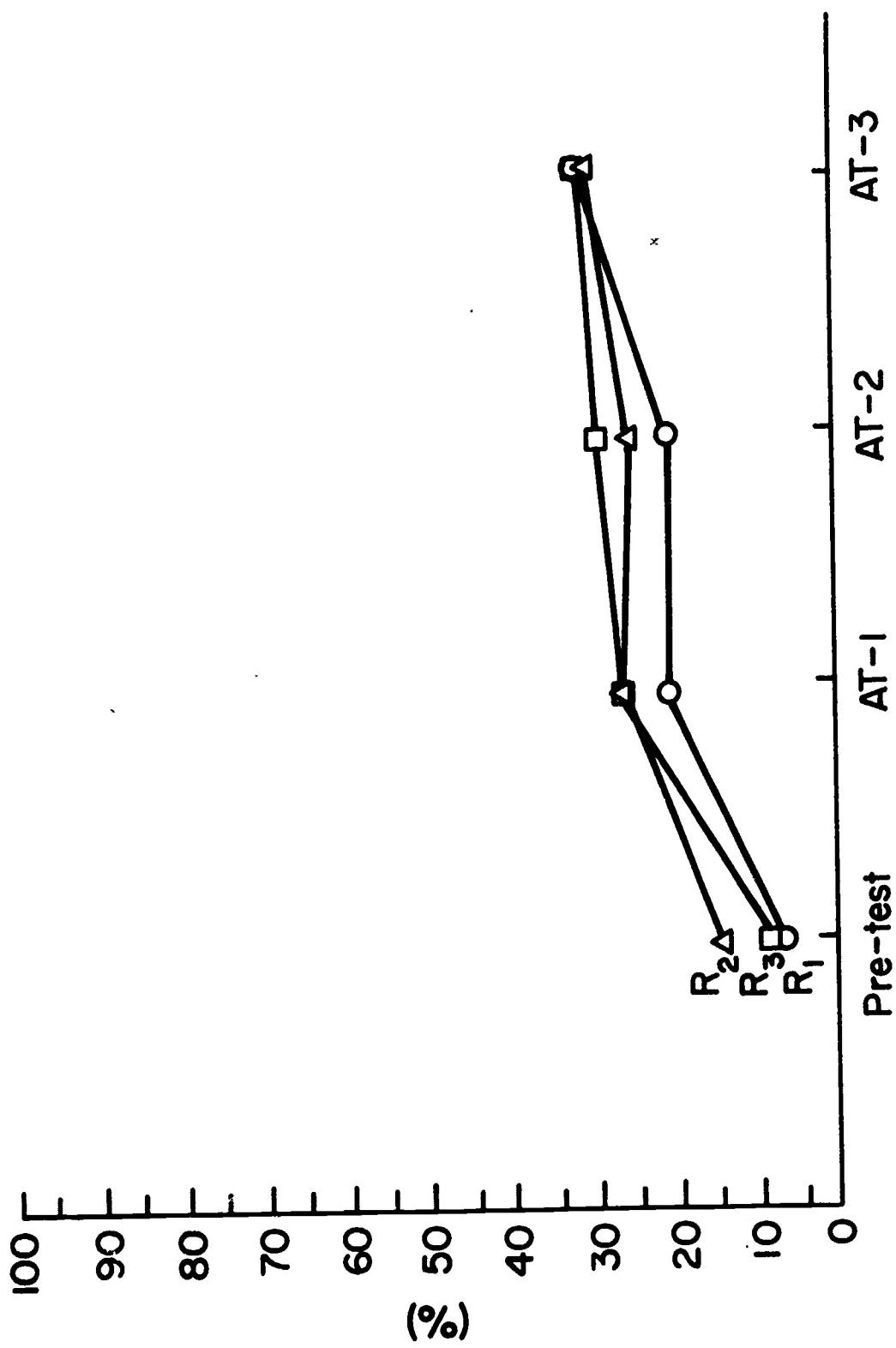


Figure 9 - Plot of Student Talk Variable over the Four Taping Sessions by Treatment Group

### Polynomial Regression Results: Three Tapes

Data from only the three science lessons audiotaped in the elementary schools were also analyzed by polynomial regression to determine if the information would differ from that resulting when data from the pre-test lessons (involving peers acting as ninth grade students) were included.

When only the three audiotaped lessons were analyzed, a different picture resulted. Fewer variables were found to have F-ratios at or above the .05 level of significance. The variable of Teacher Talk, the only one of the three criterion variables found to have an F-ratio at the .05 level of significance when data from the four taping sessions were combined, did not exhibit an F-ratio at the .05 level of significance for any of the three treatment groups.

The criterion variable of Pause Time did exhibit an F-ratio at the .05 level of significance for treatment group R<sub>2</sub> when only the three lessons audiotaped in the elementary schools were analyzed.

Table 25 - F-Ratios Resulting from Analysis of Variance  
for Polynomial Regression, Goodness of Fit  
Test, for Pause Time Variable

Polynomial	Treatment Group					
	R <sub>1</sub>		R <sub>2</sub>		R <sub>3</sub>	
	F	df	F	df	F	df
1st degree (linear)	0.29	(1,16)	4.97	(1,19)	0.22	(1,40)
2nd degree (quadratic)	0.98	(2,15)	2.35	(2,18)	0.75	(2,39)
Critical values at .05 level	R <sub>1</sub>	= 4.49	R <sub>2</sub>	= 4.38	R <sub>3</sub>	= 4.08

Figure 10 illustrates the plot of the Pause Time variable over the time period involved in Quarter Two of the study for the three treatment groups.

When the polynomial regression data for treatment group R<sub>1</sub> were analyzed, the variable of per cent of Rhetorical Questions was found to exhibit an F-ratio at the .05 level of significance. This information is contained in Tables 26 and 27 and Figure 11.

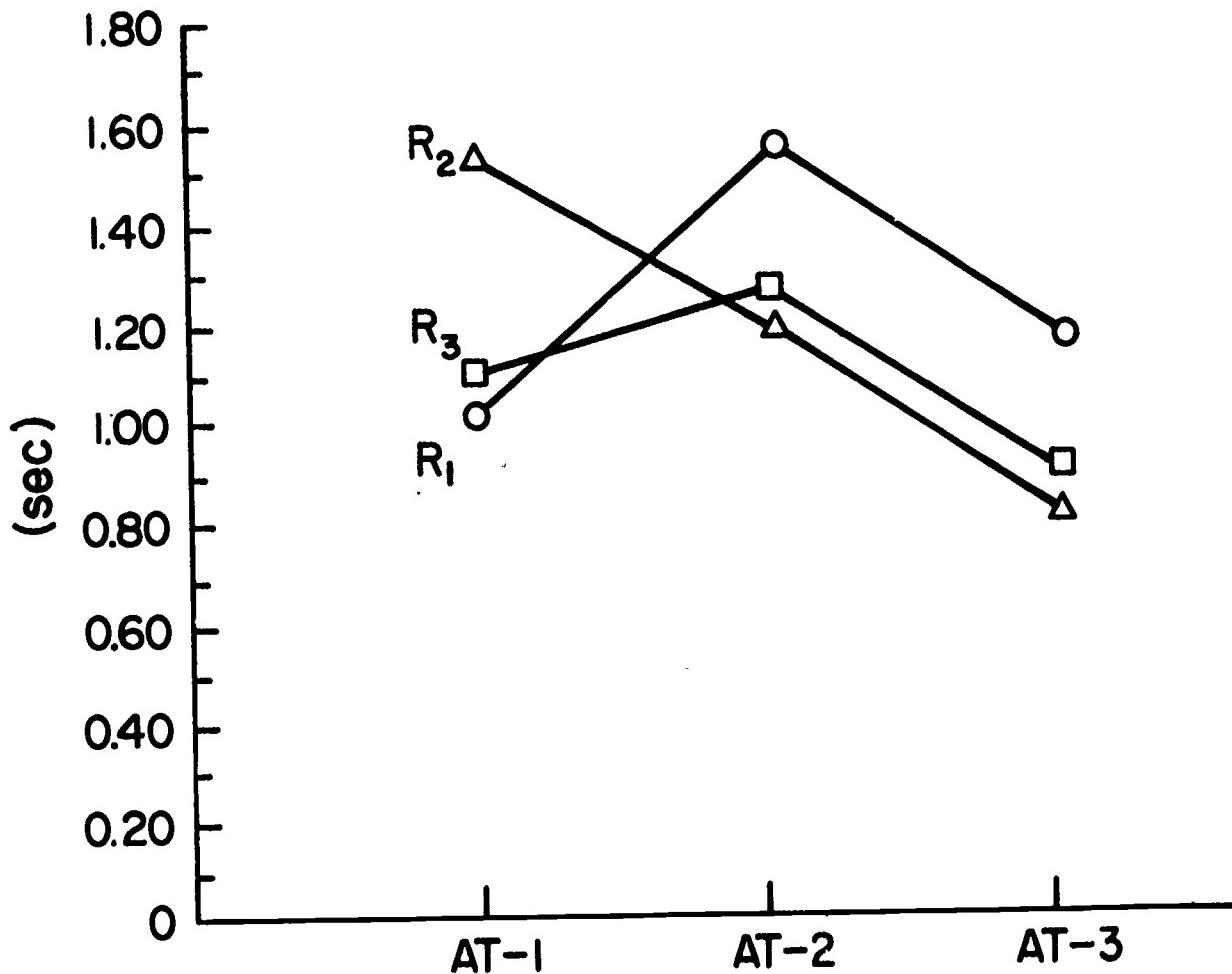


Figure 10 - Plot of Pause Time Variable over the Three Audiotapes by Treatment Group

Table 26 - F-Ratios Resulting from Analysis of Variance for Polynomial Regression, Goodness of Fit Test, for Per Cent Rhetorical Questions Variable

Polynomial	Treatment Group		
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>
1st degree (linear)	7.01	0.02	1.83
2nd degree (quadratic)	3.26	0.22	0.96

Table 27 - Means for Rhetorical Question Percentages Variable for the Three Audiotapes by Treatment Group

Treatment Group	Taping Session		
	AT-1	AT-2	AT-3
R <sub>1</sub>	13	04	02
R <sub>2</sub>	06	07	05
R <sub>3</sub>	08	06	05

The plot of the trend of the variable of per cent of Rhetorical Questions over time is shown in Figure 11.

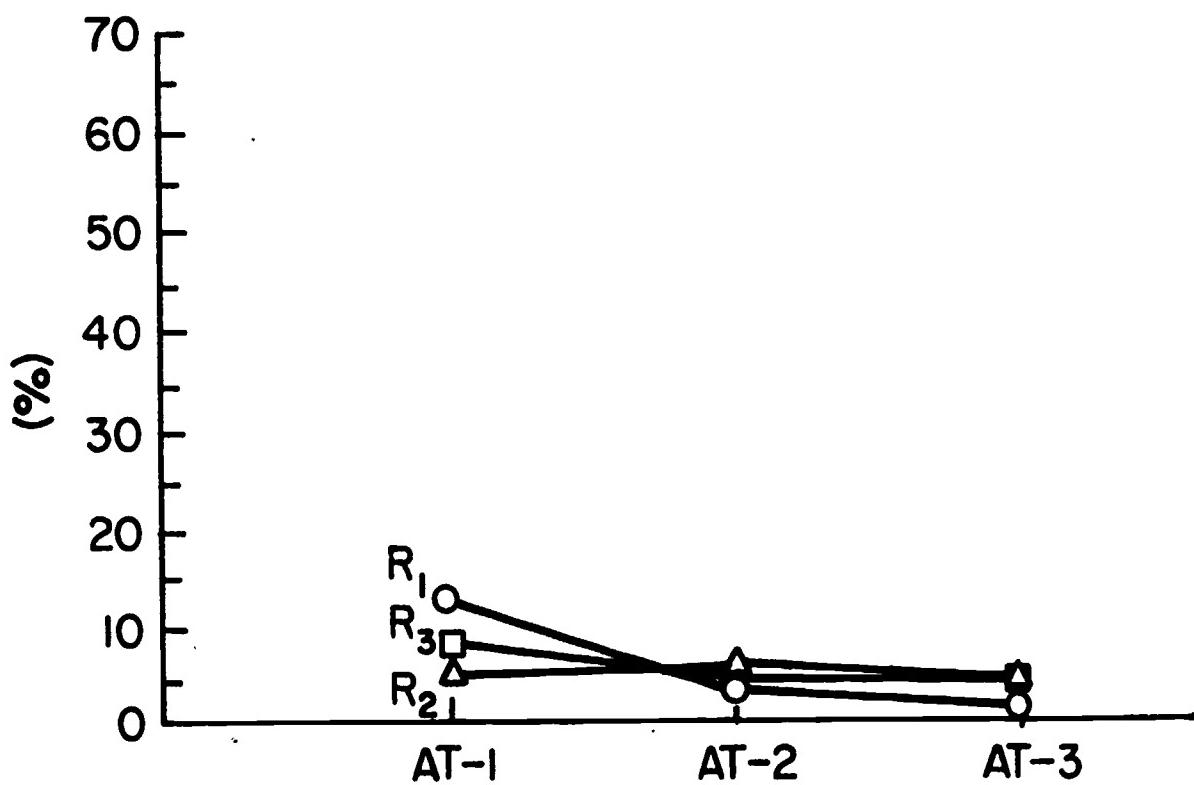


Figure 11 - Plot of Percent Rhetorical Questions Variable over the Three Audiotapes by Treatment Group

The variable of the percentage of Managerial Questions had been found to exhibit an F-ratio, linear regression, at the .05 level of significance for treatment group  $R_1$  when data from the four taping sessions were analyzed by polynomial regression. When pre-test data were removed from the analysis, the variable of percentage of Managerial Questions was still found to exhibit an F-ratio at the .05 level of significance. However, in the data analysis for the three audiotapes, this F-ratio was found in treatment group  $R_3$ .

Table 28 contains information relative to the analysis of variance results for the per cent Managerial Questions variable for the three audiotapes.

Table 28 - F-Ratios Resulting from Analysis of Variance for Polynomial Regression, Goodness of Fit Test, for Per Managerial Questions Variable

Polynomial	Treatment Group		
	$R_1$	$R_2$	$R_3$
1st degree (linear)	1.50	0.08	6.02
2nd degree (quadratic)	1.45	0.06	3.02
Critical values at .05 level	$R_1 = 4.49$ , df = 1,16 $R_2 = 4.38$ , df = 1,19 $R_3 = 4.08$ , df = 1,40		

The means for the Managerial Question Percentage variable are presented in Table 22. The plot for the variable for the three audio-taping sessions is shown in Figure 12.

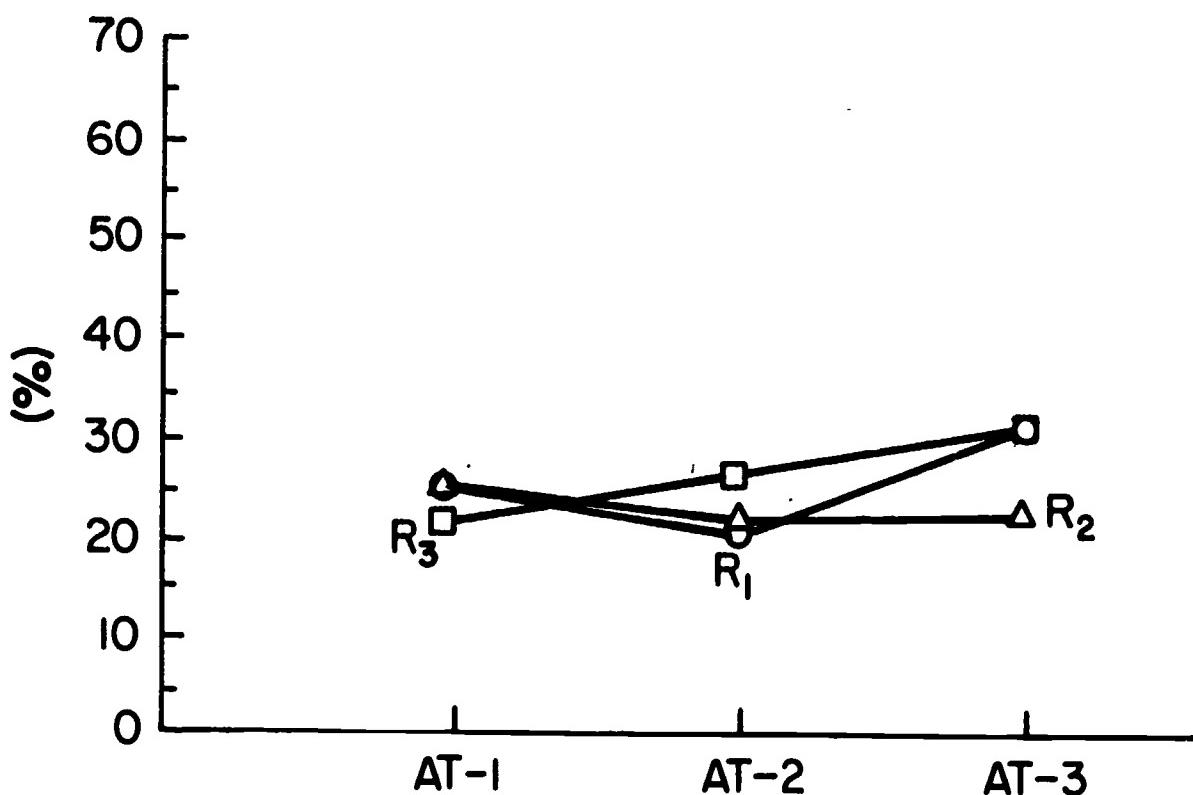


Figure 12 - Plot of Managerial Question Percentages Variable over the Three Audiotapes by Treatment Group

## INTERPRETATION OF RESULTS

In this section, each of the hypotheses will be treated separately, using appropriate data reported in the preceding section of this report.

### Hypothesis 1

Hypothesis 1: There is no significant effect of duration (massed vs. distributed practice) of the instructional sequence on skill development in questioning. When the three criterion variables assumed to provide evidence for questioning skill development: Open Questions, Pause Time, and Teacher Talk are considered, Hypothesis 1 cannot be rejected.

There were no significant differences (.05 level) between treatment groups for the variables of Open Questions, Pause Time mean, and Teacher Talk.

It would appear that, for the sample population of this study, neither the massed practice of five group sessions taking place within a seven-week period (treatment groups R<sub>2</sub> and R<sub>3</sub>) nor the more distributed practice of five group sessions spread over a fourteen-week period (treatment group R<sub>1</sub>) differed in effectiveness in causing the subjects to develop skill in asking Open Questions.

There was a significant interaction between treatment and audiotaping (see Table 9) at the .10 level of significance for the variable of Pause Time. When the difference in means between the Pause Time means of treatment groups R<sub>1</sub> and R<sub>2</sub> for the first audiotaping (see Table 10 and Fig. 1) was tested, using a t-test of the significance of the difference between two means for independent samples, this difference was not significant.

Again, there was a significant difference for the interaction of audiotaping with treatment group for the variable of Teacher Talk (see Table 12) but there was no significant difference between treatment groups for this variable.

Hypothesis 1 could not be rejected on the basis of the evidence available in this study.

### Hypothesis 2

Hypothesis 2: There is no significant trend over time in development of questioning skill. The results of the tests of this hypothesis will be discussed first in terms of the three criterion variables: Open Questions, Pause Time, and Teacher Talk. Additional variables for which significant effects were identified by polynomial regression analyses will also be included in the discussion.

When the criterion variable of asking Open Questions is considered, there was no significant trend in questioning skill development as evidenced by this variable.

The largest mean percentage of Open Questions asked by any of the treatment groups was a mean of 15 per cent, asked by the members of treatment group  $R_3$  during the pre-test lesson. It should be recalled that the pupils for the pre-test lessons were peers who had been instructed to play the roles of ninth grade students. These microteaching lessons were videotaped in the early part of Quarter One of the study, before the college students had had much experience in the public schools.

When the pupils were elementary school children, the largest mean was 12 per cent Open Questions asked during the first audiotaping session, by treatment group  $R_3$ . The mean for treatment group  $R_3$  decreased for audiotape two and increased slightly for audiotape three.

Treatment group  $R_1$  exhibited a trend over time similar to that of treatment group  $R_3$ : a decrease from first to second audiotapes and a slight increase for the third audiotape.

Treatment group  $R_2$  had the same mean percentage (10%) of Open Questions for each of the three lessons audiotaped in the elementary schools. The trend over time did not vary for the lessons recorded during Quarter Two of the study for treatment group  $R_2$ .

The criterion variable of Pause Time, when tested by polynomial regression analysis techniques, did not exhibit any F-ratios at the .05 level of significance for any of the treatment groups when data from the four taping sessions were considered (see Table 18). However, when pre-test data were not included and only data from the three lessons audiotaped in the elementary schools were analyzed, the variable of Pause Time exhibited an F-ratio for linearity at the .05 level of significance for treatment group  $R_2$  (see Table 25).

The plot of the Pause Time variable over the four taping sessions is shown in Figures 7 and 10, for the three audiotaping sessions. When the trend over time is studied for the four tapes, it is apparent that the Pause Time mean drops from the pre-test tape to the first audiotape in the schools for both groups  $R_1$  and  $R_3$ . The mean of Pause Time increases from the pre-test tape to the first audiotape for treatment group  $R_2$ .

As the audiotaping continues, the Pause Time mean increases for both groups  $R_1$  and  $R_3$  for the second audiotape and then decreases for the third. The Pause Time mean for treatment group  $R_2$  continues to decrease, despite the fact that treatment group  $R_2$  was the group currently receiving instruction in questioning.

When inspecting the plot of the Pause Time variable over time, it is apparent that group R<sub>1</sub> made the largest gain in pausing from audiotape one to audiotape two, although group R<sub>3</sub> also showed an increase in Pause Time. There is a possible interpretation for this circumstance. Treatment group R<sub>3</sub> had received instruction in questioning during the first quarter of the study, following the pre-test lesson. All of the instruction for treatment group R<sub>3</sub> was completed during Quarter One of the study. Treatment group R<sub>1</sub> received the largest portion of instruction during Quarter One of the study (see Appendix B for details of the instructional sequence). The remainder of the instruction took place after the first audiotaping in the schools and before the second audiotaping.

In addition, members of all three treatment groups were asked to listen to their audiotape and complete a self-evaluation of their questioning behavior, using a form supplied by the investigator (see Appendix E). Following this self-evaluation, members of treatment groups R<sub>1</sub> and R<sub>2</sub> had mandatory evaluation conferences with the investigator in which they discussed their questioning abilities and methods for possible improvement. These individual conferences were optional for members of treatment group R<sub>3</sub>. The majority, but not all, of the members of treatment group R<sub>3</sub> chose to take advantage of the opportunity to discuss their questioning techniques.

Members of treatment groups R<sub>3</sub> and R<sub>1</sub> had had the opportunity to assimilate information about questioning prior to working with small groups or the total class in a discussion situation. Members of treatment group R<sub>2</sub> were receiving the instruction concurrent with their attempts to put it into practice. It would appear that, for the behavior of pausing in order to allow students time to think, prior instruction combined with review, reinforcement and evaluation (self, other) was more effective in producing an increase in Pause Time than was either prior instruction with self-evaluation or concurrent instruction combined with evaluation (self, other).

It would also appear, based on viewing the trend over time of the Pause Time mean for treatment group R<sub>2</sub>, that providing individuals with some instruction in a particular skill concurrent with expecting them to demonstrate some competency in that skill is the least effective situation. Members of treatment group R<sub>2</sub> received instruction in questioning, read and discussed the material contained in the handbook on questioning techniques (developed by the investigator), and were apparently able to accept the rationale for pausing and to demonstrate this behavior during the first audiotape. As their teaching continued, they appeared to become less concerned with using this questioning technique (see Table 25 and Fig. 10).

There was a change in Pause Time mean over tapings in the elementary schools. Although the Pause Time mean increased for two groups (R<sub>1</sub> and R<sub>3</sub>) for the second audiotaping, it decreased for the third

audiotaping. A possible explanation for this occurrence might be that the self-evaluation continued but that conferences with the investigator were optional and at the discretion of the pre-service teacher. A few asked for additional conferences but the majority did not. The inference may be made that the pre-service teachers were not sufficiently sophisticated in the self-evaluation of questioning to be able to analyze their behavior and to develop alternatives designed to improve their questioning techniques. When additional guidance and instruction were not provided, any gains that had been made were cancelled by the demands of teaching and the existing situation in the classroom.

The criterion variable of Teacher Talk exhibited an F-ratio at the .05 level of significance when data from the four taped lessons were subjected to polynomial regression analysis. There was a linear regression of this variable for each treatment group (see Table 17). When the data relative to the pre-test lessons were removed from the polynomial regression analysis and only the three lessons audiotaped in the schools were considered, there were no F-ratios at the .05 level of significance for any of the treatment groups.

Although the trend over time was a linear one, indicating a decrease in teacher talk (see Figure 5), this decrease in teacher talk may have been produced by a change in pupil population rather than by instruction in questioning techniques. The means for Teacher Talk decreased markedly when the pre-test data are compared with those of the first audiotape (see Table 18). In the previous study on questioning skill development completed by the investigator (4), subjects who received instruction in questioning were able to exhibit decreased Teacher Talk during the instructional sequence. They were not able to demonstrate decreased Teacher Talk at a level of significance (.10 level) during their student teaching in the public secondary schools.

Relating this information to that of the study being currently reported, it seems possible to infer that some of the reduction in Teacher Talk was due to instruction in questioning although the influence of having children as pupils (as compared to peers in the pre-test lessons) cannot be ignored.

The means for the Teacher Talk variable in this study are lower than the average amount of Teacher Talk stated by Flanders\* who said that, in most classrooms, 70 per cent of the time some one is talking and 70 per cent of that time, the speaker is the teacher. The majority of the studies of classroom interaction which this investigator has reviewed do not contain reports of percentages of Teacher Talk which

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\*Flanders, N.A. Teacher Influence, Pupil Attitudes, and Achievement. Washington: U.S. Department of Health, Education and Welfare, Office of Education, Cooperative Research Monograph No. 12.

are as low as those identified in this research project. Many of the studies of classroom interaction in science lessons have been completed at the secondary school level. It is not possible, therefore, to make any comparisons and generalizations about the effectiveness of the instruction in questioning vs. the pupil population involved relative to the amount of Teacher Talk reported for the individuals involved in this research and in the populations in other research studies.

A possible explanation of the marked decrease in Teacher Talk during Quarter Two of the study involves both questioning behavior of the pre-service teachers and the behavior of their pupils. The pre-service teachers had been emphatically told that "effective" teachers (those who make it possible for their pupils to learn) do not dominate the verbal interaction of the classroom. The investigator had attempted to personify this model (a teacher who acted as a facilitator rather than a lecturer) during the instructional sequence on questioning and encouraged much interaction by, and among, students during the meetings. If the pre-service teachers accepted this model as a desirable one, and they apparently did--judging from comments in their written logs and in seminar discussions, they no doubt planned and conducted their science lessons so that student talk was encouraged (see Tables 21, 22, and Fig. 9). They acted to decrease Teacher Talk and, as a concomitant effect, to allow for increased Student Talk.

In addition, elementary school children are, for the most part, open, affectionate, and eager to please their teachers. The pre-service teachers wanted to encourage their students to respond so they asked questions which their pupils would have a chance of answering correctly and operated primarily at the level of factual-recall, using Closed Questions. The children knew the information about which they were questioned and were eager to respond.

This situation resulted in a decrease in Teacher Talk (as well as a decrease in Pause Time) for all three treatment groups. The trend over time, for the three lessons audiotaped in the elementary schools, for treatment group R<sub>1</sub> was for a decrease in the mean of Teacher Talk from audiotape one to audiotape two followed by an increase in Teacher Talk mean for audiotape three. The decrease between tapes one and two may, again, reflect the influence of the remainder of instruction, and self-evaluation combined with the evaluation conference with the investigator.

Treatment groups R<sub>2</sub> and R<sub>3</sub> exhibited an increase in the mean of the Teacher Talk variable between audiotapes one and two, followed by a decrease for the third audiotape. Although the trend over time is similar for both of these treatment groups, treatment group R<sub>2</sub> exhibits more Teacher Talk than does R<sub>3</sub>. Again, it may be speculated that instruction provided prior to the time of application of a skill or behavior is more effective than instruction provided concurrent with application, at least for the individuals involved in this study.

In testing Hypothesis 2, relative to the significant effects of time on questioning skill development, some variables in addition to the criterion variables were examined because they exhibited F-ratios at the .05 level of significance when the data were analyzed, using polynomial regression techniques. The variable of Managerial Questions exhibited a significant (.05 level) F-ratio for treatment group R<sub>1</sub> when data from the four taping sessions were analyzed (see Table 21). When the means for Managerial Questions were reviewed (see Table 22) and the variable was plotted over time (Fig. 8) Treatment group R<sub>1</sub> appeared to increase the mean percentage of Managerial Questions asked during Quarter Two of the study, at least compared with the mean for this variable for the pre-test lessons.

However, when data for only the three lessons audiotaped in the elementary schools during Quarter Two of the study were analyzed by polynomial regression, to test Hypothesis 2, treatment group R<sub>1</sub> did not exhibit any significant F-ratios. Instead, treatment group R<sub>2</sub> was found to exhibit a significant F-ratio for linearity for Managerial Questions, indicating a decrease in the percentage of Managerial Questions over time (see Table 28, and Fig. 12) in the elementary school.

There was no particular emphasis placed on the use of Managerial Questions. The pre-service teachers involved in the study were made aware of the characteristics and uses of Managerial Questions but no direct effort was made to modify their use. Any changes over time in the percentage of Managerial Questions asked during a lesson resulted from interaction of teacher and pupils and the flow of the lesson rather than from instruction in questioning.

The variable of Student Talk also exhibited an F-ratio at the .01 level of significance when the four tapes were analyzed by the use of polynomial regression analysis (Table 23). When polynomial regression was used with only the lessons audiotaped in the elementary schools, the variable of Student Talk no longer exhibited any F-ratios at a level of significance (.05). It would appear, then, that the pupil population was primarily responsible for the change in the amount of Student Talk. When Student Talk was plotted over time for the four tapes (Fig. 9) there was seen to be an increase in the mean of this variable over time for the four tapes. The circumstances of the lesson rather than any instruction in questioning probably produced the changes identified in Student Talk.

When polynomial regression techniques were used to analyze the data resulting from the analyses of the lessons audiotaped in the elementary school, the variable of Rhetorical Questions was found to exhibit a significant F-ratio (.05 level) for treatment group R<sub>1</sub> (Tables 26 and 27). When this variable was plotted over time, the mean percentage of Rhetorical Questions asked was found to decrease.

No particular emphasis was placed on the avoidance of Rhetorical Questions during the instructional sequence. However, the fact was emphasized that by decreasing the use of Rhetorical Questions, a teacher could decrease the amount of Teacher Talk. Changes over time in the use of Rhetorical Questions were also probably influenced by circumstances in the classrooms but instruction in questioning and taping appear to have helped to produce the decrease for treatment group  $R_1$ .

To summarize the interpretation of the results used to test hypothesis 2 concerning significant effects of time on questioning skill development, the data which bear most directly on this hypothesis appear to result from the polynomial regression analysis results involving the three science lessons audiotaped in the elementary schools. Rejection or non-rejection of this hypothesis is based on data concerning the three criterion variables: Open Questions, Pause Time, and Teacher Talk. Hypothesis 2 cannot be rejected for the variable of Open Questions. It can be rejected for the variable of Pause Time, based on the evidence that the Pause Time mean decreased over time for treatment group  $R_2$ . Hypothesis 2 cannot be rejected for the variable of Teacher Talk.

### Hypothesis 3

Hypothesis 3: There are no differential effects in treatments across audiotaping sessions for the criterion variables: Open Questions, Pause Time, Teacher Talk. Some of the interpretation of the results relative to testing this hypothesis have previously been elaborated upon in the interpretation of results relative to Hypothesis 2. However, the primary sources of information used to test this hypothesis are found in the results of the multiple comparison analysis of variance tests.

With respect to the criterion variable of Open Questions, there were no significant effects with respect to the interaction of audiotape and treatment group (Table 8). Hypothesis 3 cannot be rejected with respect to this particular criterion variable.

There was a significant effect at the .10 level of significance for the variable of Pause Time but not at the .05 level of significance which was chosen as the alpha level for this study (Table 9). Hypothesis 3 cannot be rejected with respect to the criterion variable of Pause Time.

There was significant interaction effect at the .05 level of significance for the criterion variable of Teacher Talk for the interaction of audiotape with treatment group (see Table 12). Hypothesis 3 can be rejected with respect to the criterion variable of Teacher Talk.

When the means of the Teacher Talk variable (adjusted for covariance) were graphed across audiotapes one, two and three by treatment groups, the trend over time for groups  $R_2$  and  $R_3$  was similar (See Fig. 3).

Both groups exhibited an increase in the mean percentage of Teacher Talk from audiotape one to audiotape two, followed by a decrease for audiotape three. Treatment group R<sub>1</sub> decreased the mean percentage of Teacher Talk from audiotape one to audiotape two, followed by an increase for audiotape three.

When the mean percentages of Teacher Talk were graphed across treatment groups by audiotapes (see Fig. 4), the respective positions of the three treatment groups were found to differ for different taping sessions. For both audiotapes one and three, treatment group R<sub>1</sub> exhibited the largest mean percentage of Teacher Talk. For audiotape two, treatment group R<sub>2</sub> had the largest mean percentage of Teacher Talk.

If the means for only audiotape three are inspected, treatment group R<sub>2</sub> is found to have the smallest mean percentage of Teacher Talk. Having recent instruction combined with instruction in questioning concurrent with application in the classroom may have resulted in a differential effect for the variable of Teacher Talk for treatment group R<sub>2</sub>.

In summary, Hypothesis 3 cannot be rejected for the criterion variables of Open Questions and Pause Time. Hypothesis 3 can be rejected for the criterion variable of Teacher Talk.

#### CONCLUSIONS

Generalizations involving the results of this study are limited by the characteristics of the population sampled and by the accuracy of the interpretations of the data obtained.

This group appears representative of the population of prospective secondary school science teachers enrolled at The Ohio State University. Based on changes identified in this study, it appears that skill development in questioning is best facilitated by moderate to extensive instruction prior to the demonstration of the behaviors in the schools as recorded on audiotape. Review appears to increase the benefit of prior instruction and audiotaping. The Pause Time mean increases more under these conditions than if little instruction has occurred prior to audiotaping. The effect of the audiotaping on the reduction of Teacher Talk is greater when the subject has had previous instruction of a distributed nature.

The subjects' frequency of using Rhetorical Questions decreases significantly with the instruction on questioning and the audiotaping sessions. Because the greatest reduction in the use of Rhetorical Questions occurs between the first and second audiotapings, it would seem that the tape sessions had a great influence. The significant

reduction in use of Rhetorical Questions comes primarily in the data for treatment group R<sub>1</sub> which had distributed instruction.

The results would support providing questioning instruction in a distributed fashion to the students and then holding an audiotaping session with follow-up activities for maximum change. If this were done in cycles, with a different major emphasis in each cycle, it might be possible to get the maximum gain for the skill being emphasized as well as perhaps providing an effect needed to increase retention of all the other questioning behaviors.

If questioning is a teaching skill that does not differ markedly in acquisition from other skills stressed in science methods courses, specifically those related to laboratory techniques, the results of this study may support the contention that the enrollment of pre-service science teachers in methods concurrent with student teaching is not an effective way to promote skill development and utilization. Perhaps a more efficient (in terms of skill development and acquisition over time) curriculum design is that in which methodology and relevant background information are provided pre-service teachers before these individuals are asked to use the techniques in actual teaching situations. This introduction and practice would be followed later by review and more practice as the pre-service teachers attempt to use the teaching techniques in public school classrooms.

The questioning behavior of decreasing Teacher Talk to provide more time in class for pupil talk appears the most easily acquired of the three criterion behaviors involved in the study. Working with children, rather than with peers, during the instructional sequence appears to be the better practice situation for decreasing Teacher Talk.

Learning to pause after asking a question appears to be the next behavior to be acquired. If, however, a pre-service teacher who has developed some degree of skill in pausing does not make an effort to emphasize the fact to his pupils that they are expected to use this pause time to think before volunteering a response, the purpose of pausing is negated.

The skill of asking Open Questions appears to be the most difficult to learn. If one were allowed to extrapolate beyond the data at hand, the inference might be made that only after individuals gain confidence in themselves in the role of teacher are they able to develop consistent skill in asking Open Questions.

Skill development in questioning as exemplified by the teacher behaviors of asking Open Questions, pausing, and decreasing the percentage of teacher talk should be considered with respect to the type of student population as well as to lesson objectives and to the duration of the instructional sequence. Conditions in the classroom may have more influence on the questioning behaviors exhibited than do instruction and practice insofar as pre-service teachers are concerned.

Pre-service teachers need to gain experience in evaluating their questioning performance but they also need guidance and reinforcement as they gain experience in both teaching and questioning.

If pre-service teachers are expected to evidence ability to utilize questioning skills in the classroom, the expectation of such evidence must be stressed. It must not be assumed to result as an outcome of having to tape-record a science lesson. If questioning skills are considered important enough to acquire that time is set aside for the practice of the skill, then perhaps the demonstration of the desired questioning behaviors must play a greater part in the final evaluation of the pre-service teacher's classroom behavior. Being able to demonstrate skill on demand does not provide any guarantee that the pre-service teacher will continue to practice and use this skill when not observed and evaluated. It does, however, provide some external reinforcement of the importance of questioning as a teaching technique.

Questioning behavior does appear to change over time although the changes are not always significant ones, in the statistical sense, nor are the changes always in the directions desired. Periodic refresher or review sessions about questioning techniques appear to influence the development of skill in questioning. College juniors do not appear to be sufficiently experienced in self-evaluation to be able to identify areas in which they need to modify their questioning behavior. Closer supervisory contact relative to questioning appears necessary if desired gains are to be maintained over time and experience in working in the public school classrooms where many individuals and factors demand the pre-service teacher's time, energy, and concern.

Questioning behavior may be influenced not only by practice, the point in a pre-service teacher's educational program at which he is made aware that questioning techniques are a skill that can be learned and developed, the student population, the objectives of the lesson, and the duration of instruction, but also by the pre-service teacher's perception of his primary responsibility as a science teacher (transmitter of knowledge vs. facilitator of learning).

#### RECOMMENDATIONS

There are several recommendations which should be made relative to further research. Although the length of the instructional sequence used in this study was longer than that involved in the previous doctoral research, the individuals involved in the most recent research project were no more able to develop the skill of asking Open Questions at a level of significance than were the subjects of the doctoral study. Perhaps some modifications of the instructional sequence need to be made to provide greater emphasis and/or more opportunities to practice

formulating and using Open Questions. These modifications then need to be tested to determine how performance is changed.

Perhaps, as has been inferred earlier in this report, pre-service teachers lack sufficient confidence in themselves in the role of teacher as well as sufficient experience in working with pupils to be willing to attempt to use Open Questions in class discussions. The use of Open Questions may be termed a "high risk" teaching strategy in that Open Questions, by the very nature of their definition (having a wide range of acceptable responses), imply that part of the control of the content and flow of the discussion is delegated to the pupils involved rather than being the sole responsibility of the teacher.

Research needs to be done to determine how pre-service teachers feel about allowing their pupils to share in the control of the class discussions. Pre-service teachers could then be grouped for analysis purposes on the basis of their willingness to share control and their questioning behavior during and after instruction could be analyzed.

An additional factor which should be tested is the influence of a pre-service teacher's perception of his major function as a science teacher. Do individuals who consider their primary purpose to be the transmission of a large body of factual information respond differently to instruction in questioning and perform differently in the science classroom than do those individuals who consider that, as science teachers, their primary aim should be to help their pupils to be independent learners?

How much influence does practice with peers rather than with pupils of the age the pre-service teacher plans to teach have on the resultant demonstration of a teaching behavior such as questioning when the pre-service teacher works in the public schools? More research concerning this question needs to be done.

The students who participated in the present study were tested for questioning skill development while they were working with an age group which was unfamiliar to them and which they did not plan to teach upon graduation from college. Further research needs to be done on the questioning behaviors of pre-service teachers when they are working at the secondary school level, to determine if their questioning behavior in junior and senior high school science classes differs from the questioning behavior they use when working with elementary school children.

A longitudinal study should be conducted in which the individuals who participated in the present study are observed when they become secondary school science teachers to determine how their behavior changes with time and additional teaching experience.

Research needs to be done to determine the optimal pattern of instruction in questioning for pre-service teachers who are enrolled

in an undergraduate program that involves more than the customary two quarters of work in the major area. Given continued contact with a pre-service teacher, how frequently and at what points in the undergraduate program should the college supervisors emphasize questioning behavior?

A research study might be designed in which one treatment group taught peers while a second group worked with pupils of the age level they would ultimately teach. If the population were sufficiently large, two additional treatment groups might be included; one in which peer teaching was combined with a series of videotaped lessons in which desired questioning behaviors were modeled, and a second in which the use of the model tapes was combined with teaching public school pupils during the instructional sequence in questioning.

Research might be conducted in a controlled experiment to determine what influence the effect of a grade in questioning skill demonstration made in questioning behavior during the time for which the grade was assigned and in subsequent teaching when the pressure of having to demonstrate questioning ability for evaluative purposes, other than self-evaluation, was removed.

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## APPENDIX A

### A STUDY OF THE DEVELOPMENT OF THE SKILL OF EFFECTIVE QUESTIONING BY PROSPECTIVE SECONDARY SCHOOL SCIENCE TEACHERS

by

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The Ohio State University, 1970

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#### ABSTRACT

The major problem investigated was to assess the effectiveness of an instructional procedure designed to develop skill in questioning, as a teaching technique, by prospective science teachers. Subproblems investigated were (a) to determine if skill developed during this instructional sequence would transfer to the student teaching experience and (b) to determine possible relationships of selected personality factors to the development of questioning skill.

The study extended over three quarters. A total of forty-two pre-service secondary school science teachers were involved. The student teachers were given the Otis Quick-Scoring Mental Ability Test, Gamma Test, Form Em, to measure intelligence; the Myers-Briggs Type Indicator, Form E, to measure personality type; and the Educational Set Scale by Siegel and Siegel, to measure educational set.

During each quarter the subjects were randomly assigned to one of four groups: R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, and R<sub>4</sub>. A brief design of the study is as follows:

<u>Group</u>	<u>Pretest</u>	<u>Treatment</u>	<u>Post-test</u>
R <sub>1</sub>	Yes	Teachers for instructional procedure	Yes
R <sub>2</sub>	Yes	Student-evaluators for R <sub>1</sub>	Yes
R <sub>3</sub>	Yes	None	Yes
R <sub>4</sub>	No	None	Yes

Randomly selected students from each of the four groups were observed during student teaching to determine if skill gained in the instructional sequence would transfer to the reality of student teaching and to determine the effects of time and student teaching on questioning skills. Lessons observed were audiotaped for subsequent analysis.

A panel of three judges analyzed the videotaped post-test lessons for types of questions asked. Audiotapes were analyzed by the investigator. Additional analyses were done to identify behaviors emphasized as a part of the instructional sequence. The data obtained from the lesson analyses and data obtained through the use of the written instruments were subjected to parametric statistical analyses to test the seven hypotheses of the study.

These hypotheses were: (1) Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence; (2) There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on questioning behavior; (3) The skill developed during the instructional sequence will not transfer to the student teaching experience in the public schools; (4) There is no relationship between intelligence and questioning behavior; (5) There is no relationship between sex and questioning behavior; (6) There is no relationship between educational set and questioning behavior; (7) There is no relationship between personality type and questioning behavior.

Three criterion variables were chosen to test the hypotheses. These were (1) asking Open Questions (those having a wide range of acceptable responses), (2) pausing to allow students time to think before responding, and (3) questioning in a manner designed to decrease the percentage of teacher talk during a lesson. The .10 level of significance was used for rejection or non-rejection of each hypothesis with respect to each of the three criterion variables.

Hypotheses one and two were rejected for the criterion variables of pausing and of decreasing the percentage of teacher talk. Hypotheses one and two could not be rejected for the variable of asking Open Questions. Hypotheses three through seven were not rejected for any of the criterion variables.

The individuals involved in the study appeared representative of the population of pre-service secondary school science teachers enrolled at The Ohio State University. Questioning appeared to be a skill that could be developed, through instruction and practice, by these individuals. The development of questioning skill did not appear to be limited by intelligence, sex, personality type, or educational set, insofar as this sample was concerned.

## APPENDIX B

### INSTRUCTIONAL PROCEDURES FOR THE THREE TREATMENT GROUPS

Each of the three randomly assigned treatment groups participated in the instructional procedure on questioning techniques. All three groups were pretested during quarter one, prior to any instruction. Instruction for the members of group R<sub>1</sub> was carried out over a two quarter period. Group R<sub>2</sub> members received instruction during quarter two while members of group R<sub>3</sub> received instruction during quarter one of the study.

#### Group R<sub>1</sub>

##### A. Pretest

Students were asked to prepare and teach a 15-minute lesson in science aimed at ninth grade students, using their peers as pupils. The lesson was videotaped.

##### B. Instructional Procedure

Five sessions were involved in group instruction.  
1) Students were given a written pretest to determine prior knowledge concerning functions of questions as a teaching technique. They also received a copy of the handbook on questioning techniques and an overview of its contents. They were requested to skim the book and read the first two chapters before the next meeting on questioning.

2) Students were encouraged to ask questions concerning the Question Category System and other handbook material. They were asked to classify written questions during the session. They were asked to observe experienced teachers and to classify the questions heard during the observations.

3) Students discussed their observations and attempted to identify patterns in questioning and to relate these to other classroom observations.

(Quarter Two)

4) Students were asked to classify questions heard during a videotaped biology lesson. Questioning behaviors observed on the videotape were discussed. Students were asked to prepare a brief lesson plan involving the construction of key questions to be asked. These plans and questions were shared for group discussion and criticism.

- 5) Students independently analyzed an audiotape of their teaching of an elementary science lesson, focusing on questions asked and questioning behaviors identified. Students scheduled individual conferences to discuss the tape with the investigator.
- 6) Students again independently analyzed a second audiotape for questions and questioning behaviors. Individual conference was optional.
- 7) Group discussion of problems involved in attempting to put questioning strategies into practice in the classroom.
- 8) Independent analysis of third audiotape.

Group R<sub>2</sub>

- A. Pretest                         Same as for group R<sub>1</sub>.
- B. Instructional Procedure
  - Five group sessions were also involved.
    - 1) Same as for group R<sub>1</sub>.
    - 2) Students were encouraged to ask questions concerning the Question Category System and other handbook material. Students were asked to classify written questions. Students viewed a videotape of a biology lesson and discussed the questioning behaviors exhibited by the teacher.
    - 3) Students independently analyzed an audiotape of their teaching, focusing on questions asked and the questioning behaviors identified. Each student discussed his self-evaluation of the tape with the investigator at an individual conference.
    - 4) Students prepared a brief lesson plan involving the construction of key questions to be asked. The lesson objectives and questions were shared for group discussion and criticism.
    - 5) Students participated in a self-testing activity designed to evaluate their ability to classify questions at each of the levels of the Question Category System. The results of the activity were discussed to clarify points of confusion.
    - 6) Students independently analyzed a second audiotape of their teaching to check on questions and questioning behaviors. Individual conferences were optional.
    - 7) Group discussion of problems involved in attempting to put questioning strategies into practice in the classroom.
    - 8) Independent evaluation of the third audiotape.

Group R<sub>3</sub>

- A. Pretest                      Same as for group R<sub>1</sub>.
- B. Instructional Procedure
- Five group sessions, plus the independent analyses, were used.
- 1) Same as for group R<sub>1</sub>.
  - 2) Same as for group R<sub>2</sub>.
  - 3) The students taught microlessons, using the other individuals in the group as pupils. The questions and questioning strategies identified from the audiotapes of the lessons were discussed by the group.
  - 4) The group members taught microlessons, which were audiotaped and analyzed by the total group.
  - 5) Group discussion of problems involved in attempting to put questioning strategies into practice in the classroom, with particular emphasis to a one-to-one tutorial session and with projections toward small group interaction in the following quarter.

During quarter two, forms for the analysis of questions and questioning behavior were made available to members of group R<sub>3</sub> if they wished to undertake any self-evaluation. An opportunity for an individual conference was possible, following the required conference for groups R<sub>1</sub> and R<sub>2</sub>, but this was not a mandatory activity.

APPENDIX C  
QUESTION CATEGORY SYSTEM

QUESTION CATEGORY SYSTEM		
LEVEL I	LEVEL II	LEVEL III
<b>I. CLOSED QUESTIONS</b> (limited number of acceptable responses)	<b>A. COGNITIVE-MEMORY*</b>  <b>B. CONVERGENT THINKING*</b>	1. RECALL: includes repeat, duplicate, memorized definitions 2. IDENTIFY or NAME or OBSERVE 1. ASSOCIATE and/or DISCRIMINATE; CLASSIFY 2. REFORMULATE 3. APPLY: previously acquired information to solution of new and/or different problem 4. SYNTHESIZE 5. CLOSED PREDICTION: limitations imposed by conditions, evidence 6. MAKE "CRITICAL" JUDGMENT: using standards commonly known by class
<b>II. OPEN QUESTIONS</b> (greater number of acceptable responses)	<b>C. DIVERGENT THINKING*</b>  <b>D. EVALUATIVE THINKING*</b>	1. GIVE OPINION 2. OPEN PREDICTION: data insufficient to limit response 3. INFER or IMPLY  1. JUSTIFY: behavior, plan of action position taken 2. DESIGN: new method(s), formulate hypotheses, conclusion(s) 3. JUDGE A: matters of value, linked with affective behaviors 4. JUDGE B: linked with cognitive behaviors
<b>III. MANAGERIAL</b>	Teacher uses to facilitate classroom operations, discussion	
<b>IV. RHETORICAL</b>	Teacher uses to reinforce a point; does not expect (or want) a response	
*1. <u>Cognitive-memory</u> : evidence understood to be directly available (book, previous lesson or discussion, film or filmstrip, chart) 2. <u>Convergent thinking</u> : evidence directly available but not in form called for by question 3. <u>Divergent thinking</u> : evidence for response not directly available 4. <u>Evaluative thinking</u> : evidence may or may not be directly available; criteria for responding available, directly or indirectly. Contains implication that student may be called upon to provide a defense for his response.		

## APPENDIX D

### DEPENDENT VARIABLES INVOLVED IN THE STUDY

#### (1) Open Questions

An Open Question is defined as one for which there are more than two or three acceptable responses. Open Questions do not, in their wording, limit the area within which a student may think before voicing a response. Open Questions may be further subdivided into Divergent Thinking questions and Evaluative Thinking questions, according to the Question Category System for Science, the instrument used in this study and shown in Appendix C.

The variable of Open Questions used in this study was derived by using the Question Category System to identify the questions and then dividing the number of Open Questions identified by the total number of questions asked in the portion of the lesson selected for analysis.

#### (2) Pause Time

Pause Time is defined as a wait (pause) of at least three seconds after asking a question classified as being at a level above factual-recall, so that the students are provided with time to think before responding.

Pause Time was determined by listening to the tapes and timing the pauses (silences) of the teacher, using a stopwatch. The mean of the pause times for the segment of the lesson analyzed was used.

#### (3) Teacher Talk

A decreased percentage of Teacher Talk during a lesson was assumed to accompany the use of Open Questions and pausing to allow for thinking. If teachers ask Open Questions and allow their students time to think, they should dominate the verbal interaction in their classrooms less because they are encouraging more, and more extended student responses.

The percentage of Teacher Talk was obtained by timing the amount of Teacher Talk and dividing this by the length of the lesson segment selected for analysis. Analysis segments were selected at random from the tapes. (The percentage of student talk and of "silence" were also similarly computed although these were not considered as criterion variables.)

## APPENDIX E

### SELF-ANALYSIS/EVALUATION FORM USED BY STUDENTS

#### TAPE ANALYSIS: QUESTIONING

READ THIS CAREFULLY BEFORE BEGINNING TO LISTEN TO THE TAPE. THEN ANALYZE YOUR QUESTIONING BEHAVIOR AS YOU LISTEN.

1. In a \_\_\_\_\_ minute interval I asked \_\_\_\_\_ questions.

2. These included:

\_\_\_\_\_ Managerial Questions      \_\_\_\_\_ Closed Questions

\_\_\_\_\_ Rhetorical Questions      \_\_\_\_\_ Open Questions

(Behaviors to be encouraged)

3. I asked a student to expand a response \_\_\_\_\_ times.

4. I asked students to react to each other \_\_\_\_\_ times.

(Behaviors to be discouraged)

5. I repeated my own question or rephrased it \_\_\_\_\_ times.

6. I repeated a student's response \_\_\_\_\_ times.

7. I answered my own question \_\_\_\_\_ times.

8. I did not pause at all or only momentarily \_\_\_\_\_ times.

9. I made unnecessary comments or remarks \_\_\_\_\_ times.

GOAL:

Behaviors 3 + 4

\_\_\_\_\_  $\geq$  1

Behaviors 5 + 6 + 7 + 8 + 9

## APPENDIX F

### ADDITIONAL INFORMATION SUPPLIED AS BACKGROUND FOR AUDIOTAPED LESSONS

#### JUNIOR PROJECT: SCIENCE EDUCATION

##### QUESTIONING ANALYSIS

Directions: Please complete one of these for your audiotape, to provide data (and give background information) on your questioning techniques.

J-2 Teacher \_\_\_\_\_

School \_\_\_\_\_ Grade Level \_\_\_\_\_

Date of recording \_\_\_\_\_

1. What type of lesson was this: introductory, part way through unit, end of unit?
  
2. What happened during the previous lesson that would relate to and pave the way for what you did during the lesson which was recorded?
  
3. What activities did the class do, either individually or in groups?
  
4. What did you as teacher do that your students did not?
  
5. Aside from your questioning techniques, did you think the lesson achieved your major objective(s)? Why or why not?

JUNIOR PROJECT: SCIENCE EDUCATION  
LESSON PLAN

Teacher \_\_\_\_\_ Date \_\_\_\_\_

Grade level \_\_\_\_\_

Topic \_\_\_\_\_

MAJOR OBJECTIVE (state in behavioral terms):

RATIONALE FOR TEACHING:

PROCESS(ES):

CONCEPT(S):

MATERIALS AND EQUIPMENT NEEDED:

KEY QUESTIONS:

STUDENT ACTIVITIES:

## APPENDIX G

## STATISTICAL TABLES

Table 29 - Means and Standard Deviations of Question Type (Level 1)  
 Pause Time, and Percentage of Teacher Talk for the Four  
 Taped Science Lessons

Variable	Total Sample		R <sub>1</sub>		R <sub>2</sub>		R <sub>3</sub>	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Closed Questions <sup>a</sup>	0.60	0.18	0.65	0.25	0.70	0.14	0.53	0.14
Closed Questions <sup>b</sup>	0.57	0.16	0.54	0.17	0.59	0.12	0.58	0.19
Closed Questions <sup>c</sup>	0.63	0.11	0.69	0.14	0.60	0.10	0.61	0.10
Closed Questions <sup>d</sup>	0.56	0.13	0.58	0.08	0.62	0.10	0.53	0.15
Open Questions <sup>a</sup>	0.14	0.10	0.14	0.16	0.12	0.05	0.15	0.10
Open Questions <sup>b</sup>	0.11	0.08	0.09	0.04	0.10	0.09	0.12	0.09
Open Questions <sup>c</sup>	0.07	0.07	0.05	0.03	0.10	0.07	0.07	0.07
Open Questions <sup>d</sup>	0.09	0.09	0.07	0.06	0.10	0.08	0.10	0.10
Managerial Questions <sup>a</sup>	0.20	0.13	0.15	0.13	0.14	0.13	0.26	0.11
Managerial Questions <sup>b</sup>	0.23	0.11	0.24	0.14	0.24	0.12	0.22	0.10
Managerial Questions <sup>c</sup>	0.24	0.10	0.21	0.09	0.22	0.15	0.26	0.08
Managerial Questions <sup>d</sup>	0.30	0.12	0.32	0.11	0.22	0.10	0.32	0.13
Rhetorical Questions <sup>a</sup>	0.06	0.06	0.06	0.08	0.04	0.05	0.07	0.07
Rhetorical Questions <sup>b</sup>	0.09	0.07	0.13	0.08	0.06	0.07	0.09	0.06
Rhetorical Questions <sup>c</sup>	0.06	0.05	0.05	0.08	0.08	0.06	0.06	0.04
Rhetorical Questions <sup>d</sup>	0.05	0.05	0.03	0.03	0.06	0.05	0.06	0.06
Pause Time Mean <sup>a</sup>	1.32	0.58	1.49	0.69	1.11	0.31	1.37	0.64
Pause Time Mean <sup>b</sup>	1.22	0.62	1.04	0.65	1.56	0.69	1.12	0.55
Pause Time Mean <sup>c</sup>	1.34	0.75	1.60	0.86	1.22	0.57	1.29	0.80
Pause Time Mean <sup>d</sup>	1.04	0.45	1.26	0.58	0.88	0.46	1.02	0.37
Teacher Talk <sup>a</sup>	0.58	0.21	0.76	0.33	0.54	0.13	0.52	0.13
Teacher Talk <sup>b</sup>	0.36	0.14	0.42	0.22	0.36	0.10	0.33	0.11
Teacher Talk <sup>c</sup>	0.36	0.13	0.34	0.09	0.39	0.14	0.35	0.13
Teacher Talk <sup>d</sup>	0.35	0.09	0.39	0.08	0.34	0.08	0.34	0.09

<sup>a</sup>Tape I (15-minute microteaching lesson, ninth grade level, students were peers)

<sup>b</sup>Tape II (randomly selected 15-minute segment of science lesson for elementary school children)

<sup>c</sup>Tape III (randomly selected 15-minute segment of science lesson for elementary school children)

<sup>d</sup>Tape IV (randomly selected 15-minute segment of science lesson for elementary school children)

Table 30 - Percentages of Questions Asked in the Four Categories of Level I of the Question Category System, Pre-Test Lesson

Student	Percentage			
	Closed	Open	Managerial	Rhetorical
<u>TREATMENT GROUP R<sub>1</sub></u>				
01	54	23	15	08
10	75	00	25	00
29	31	31	31	08
32	80	00	00	20
35	50	31	19	00
39	100	00	00	00
<u>TREATMENT GROUP R<sub>2</sub></u>				
03	88	13	00	00
04	77	08	15	00
12	80	20	00	00
13	56	06	31	06
33	62	14	21	03
34	78	13	03	06
36	50	13	25	13
<u>TREATMENT GROUP R<sub>3</sub></u>				
02	76	16	00	08
07	51	28	16	05
09	42	25	33	00
15	56	00	44	00
17	44	13	38	06
19	32	26	32	11
20	53	24	24	00
22	69	00	25	06
24	51	11	37	00
25	33	11	33	22
27	64	09	18	09
30	53	26	16	05
31	71	03	21	06
38	44	17	22	17

Table 31 - Pause Time Means (sec), Percentage of Teacher Talk, by Treatment Group, Pre-Test Lesson

Student	Pause Time Mean	Teacher Talk
<u>TREATMENT GROUP R<sub>1</sub></u>		
01	1.12	51
10	2.25	80
29	1.33	52
32	1.50	63
35	2.25	73
39	0.46	63
<u>TREATMENT GROUP R<sub>2</sub></u>		
03	1.22	50
04	0.75	58
12	0.92	36
13	1.52	74
33	1.51	45
34	0.96	46
36	0.91	67
<u>TREATMENT GROUP R<sub>3</sub></u>		
02	0.80	82
07	1.65	38
09	0.73	60
15	2.44	60
17	0.94	52
19	0.61	32
20	2.06	58
22	1.64	53
24	1.16	52
25	0.58	66
27	2.14	36
30	1.67	54
31	0.76	32
38	1.93	54

Table 32 - Percentages of Questions Asked in the Four Categories of Level I of the Question Category System, Audiotape I

Student	Percentage			
	Closed	Open	Managerial	Rhetorical
<u>TREATMENT GROUP R<sub>1</sub></u>				
01	51	08	25	17
10	69	10	19	03
29	53	11	09	23
32	35	02	47	16
35	40	10	33	17
39	78	08	11	03
<u>TREATMENT GROUP R<sub>2</sub></u>				
03	42	20	18	20
04	73	23	03	00
12	57	17	22	04
13	59	04	37	00
33	48	03	40	09
34	72	03	21	03
36	64	02	28	06
<u>TREATMENT GROUP R<sub>3</sub></u>				
02	42	24	24	09
07	58	01	29	12
09	49	15	29	07
15	68	00	22	10
17	79	15	06	00
19	44	14	25	16
20	73	05	21	00
22	56	07	27	10
24	53	12	29	06
25	77	13	02	08
27	67	12	14	07
30	21	33	31	15
31	87	00	13	00
38	31	13	37	19

Table 33 - Pause Time Means (sec), Percentage of  
Teacher Talk, by Treatment Group,  
Audiotape I

Student	Pause Time Mean	Teacher Talk
<u>TREATMENT GROUP R<sub>1</sub></u>		
01	2.27	33
10	0.62	26
29	0.55	78
32	0.77	35
35	1.23	20
39	0.79	61
<u>TREATMENT GROUP R<sub>2</sub></u>		
03	0.84	43
04	1.63	18
12	0.97	37
13	1.81	32
33	1.38	50
34	1.36	40
36	2.91	32
<u>TREATMENT GROUP R<sub>3</sub></u>		
02	2.35	26
07	1.87	24
09	1.23	54
15	0.90	45
17	0.81	09
19	0.65	28
20	1.36	35
22	1.36	31
24	1.44	31
25	0.77	31
27	1.10	23
30	1.02	38
31	0.09	49
38	0.77	35

Table 34 - Percentages of Questions Asked in the Four Categories of Level I of the Question Category System, Audiotape II

Student	Percentage			
	Closed	Open	Managerial	Rhetorical
<u>TREATMENT GROUP R<sub>1</sub></u>				
01	74	06	19	00
10	74	06	21	00
29	56	04	20	20
32	52	09	36	01
35	66	03	24	08
39	92	00	08	00
<u>TREATMENT GROUP R<sub>2</sub></u>				
03	69	03	14	10
04	66	00	22	13
12	53	15	17	15
13	68	17	07	07
33	64	16	14	06
34	42	05	53	00
36	55	15	27	02
<u>TREATMENT GROUP R<sub>3</sub></u>				
02	68	00	21	11
07	64	14	16	07
09	58	06	29	07
15	67	07	17	08
17	73	09	18	00
19	67	00	20	13
20	38	25	25	13
22	60	00	40	00
24	54	00	38	08
25	66	00	31	03
27	73	09	16	02
30	44	11	36	08
31	67	07	22	05
38	60	05	30	05

Table 35 - Pause Time Means (sec), Percentage of Teacher Talk, by Treatment Group, Audiotape II

Student	Pause Time Mean	Teacher Talk
<u>TREATMENT GROUP R<sub>1</sub></u>		
01	2.65	45
10	1.12	33
29	0.76	41
32	0.65	35
35	2.18	18
39	2.25	30
<u>TREATMENT GROUP R<sub>2</sub></u>		
03	1.62	55
04	2.25	26
12	0.69	40
13	0.71	45
33	1.23	58
34	0.78	21
36	1.28	29
<u>TREATMENT GROUP R<sub>3</sub></u>		
02	1.36	31
07	1.08	20
09	1.38	39
15	0.73	35
17	2.95	09
19	1.95	47
20	2.88	50
22	0.40	52
24	0.85	48
25	0.38	13
27	1.05	39
30	1.04	32
31	1.37	46
38	0.69	35

Table 36 - Percentages of Questions Asked in the Four Categories of Level I of the Question Category System, Audiotape III

Student	Percentage			
	Closed	Open	Managerial	Rhetorical
<u>TREATMENT GROUP R<sub>1</sub></u>				
01	60	05	35	00
10	57	07	36	00
29	51	00	49	00
32	69	03	22	06
35	47	16	34	03
39	62	13	18	07
<u>TREATMENT GROUP R<sub>2</sub></u>				
03	69	00	13	17
04	74	11	11	05
12	48	19	33	01
13	57	11	29	03
33	58	21	15	06
34	55	05	34	05
36	72	04	21	02
<u>TREATMENT GROUP R<sub>3</sub></u>				
02	70	02	25	04
07	29	26	46	00
09	39	20	39	02
15	52	09	33	06
17	53	00	67	00
19	55	08	29	08
20	79	00	21	00
22	76	04	13	07
24	48	04	26	22
25	50	07	40	03
27	50	20	23	07
30	46	00	38	15
31	45	31	22	02
38	67	04	26	04

Table 37 - Pause Time Means (sec), Percentage of Teacher Talk, by Treatment Group, Audiotape III

Student	Pause Time Mean	Teacher Talk
<u>TREATMENT GROUP R<sub>1</sub></u>		
01	0.44	28
10	1.86	37
29	1.03	45
32	1.25	38
35	1.99	33
39	1.01	51
<u>TREATMENT GROUP R<sub>2</sub></u>		
03	0.83	38
04	0.55	25
12	0.76	37
13	0.86	25
33	0.64	39
34	0.67	29
36	1.89	48
<u>TREATMENT GROUP R<sub>3</sub></u>		
02	0.36	49
07	0.91	17
09	1.13	38
15	1.29	42
17	1.17	22
19	0.93	29
20	0.58	42
22	0.40	36
24	0.76	43
25	1.52	25
27	1.45	27
30	1.21	38
31	1.27	42
38	1.25	31